ABSTRACT

PARTICIPATORY LEARNING: MEASURING LEARNING AND EDUCATIONAL TECHNOLOGY ACCEPTANCE

by
Erick Sanchez Suasnabar

Participatory Learning (PL) integrates several learning approaches, engaging students throughout the entire assignment process for both online and face-to-face courses. Beyond simply providing a solution, students also craft a problem (problem-based learning), grade each other (peer assessment and feedback), evaluate themselves (self-assessment), and can view others' work (learning by example). This dissertation research explores the resulting learning effects. Contributions to both educational and Information Systems research include extending an early PL model and experiments that applied the PL approach to examinations, by validating and testing new constructs based on user activity and critical thinking. In addition, the study explores a microlearning condition. The study found that the majority of the students enjoyed being part of the PL approach for assignments while also perceiving learning benefits. Students reported learning from crafting problems, solving problems, grading and reading others' work. The extended PL model was tested and partially validated using Partial Least Squares path modeling and analysis. Recommendations for future work include improving the PL support website and the study protocol. PL has the potential to change the way students engage with their peers and assignments, thereby improving their critical thinking across many disciplines at the university level.

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by
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< I would like to dedicate this dissertation work to my parents Vilma and Fernando, and my sister Michelle for their sacrifice and hard work to help me successfully graduate. >

<Yo dedico esta dissertacion a mis padres Vilma y Fernando, y a mi hermana Michelle por su sacrificio y esfuerzo que me ayudo a graduarme satisfactoriamente.>

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

Ever since I was in middle and especially high school, I was always frustrated that coursework was rarely challenging or fun. This leads me to the following burning question that drives this research: *How can we deepen learning for everyday course assignments to make them more engaging in class?*

As a student, while I understood that constantly working on assignments would help me understand the topics taught in class, I felt that I did not need to be assigned the multiple questions on the same topic to learn it well and that quality and deeper learning were more important. In fact, when tutoring cousins, I noticed that I ended up learning more by creating mock-up questions for them and thus having to actually "know" the topic rather than just slightly modifying a problem to create a new one. This opened my eyes to an issue with my assignments, which always required just looking up details and then solving what seemed to be an arbitrary number of problems from a book. In addition, I noticed that I was more motivated when working with others rather than on my own as it seemed more fun.

After high-school, I noticed that work at college and university seemed to be more collaborative and included more peer-directed assignments. However, while I enjoyed working with my peers, these types of assignments were more the exception than the norm and I always wished there was more collaboration with other students. And I noticed that managing peer assignments involved a lot of logistical issues especially for bigger classes.

At NJIT I was introduced and begun working on the Participatory Learning (PL) approach to promote collaboration across peers while making it simple for professors to manage the assignments and quizzes. The PL approach is a new approach to quizzes and assignments that allows students to work on each stage of the assignment or quizzes including creating questions for others, solving others' questions, and then grading each other. At each stage, students had the ability to provide feedback to each other.

I am especially drawn to the PL approach because it enables students to engage in higher order cognitive activities [1] and thus engage in thinking more critically. Thus, another important motivation of my research leads me to determine: *How can we evaluate critical thinking by students?* In the PL approach, students not only work on solving a problem but also analyse and evaluate others' work to provide them with feedback and assessment through grades.

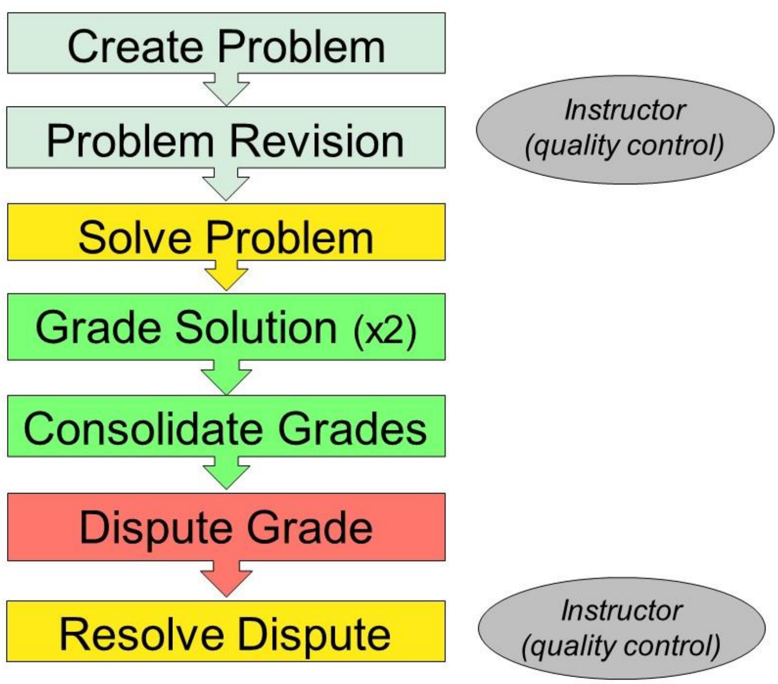


Figure 1.1 Typical PL assignment structure.

For example, Figure 1.1 illustrates one possible PL assignment structure. In this assignment structure, a student creates the problem, the instructor revises it, another student solves it, two other students grade it and a third student consolidates the grades. Finally, the student disputes the grade (optionally) and the instructor handles the dispute (Additional assignment structures are described in Chapter 3.) The PL system is a website that informs students of the current tasks and due dates in a dashboard, allows students to review previous tasks done by other students leading up to their own task, and to submit their tasks, along with many supportive features as described in Chapter 4.3.

Finally, I am driven by the question, *How can we support this complex PL approach?* Despite there being systems supporting peer collaboration, they do not offer the comprehensive range of tools, flexibility, and ready availability of the PL system to manage entire assignments from beginning to end. In the next subsection, I will outline my contributions to this study which were motivated from my own need to improve current assignments, evaluate students' critical thinking improvement, and design a system that could support the PL approach.

1.2 Approach and Contributions

Extending the work done by Wu, Hiltz, and Bieber on "Acceptance of Educational Technology: Field Studies of Asynchronous Participatory Examinations," which used a Participatory Learning (PL) approach on examinations such as final exams [2], the aim of the study is to extend the PL approach to include not only examinations but also assignments. In addition, this study aims to include a newer learning practice such as microlearning in addition to the other learning methods used in the original study.

At its core, my research seeks to explore the use of several different integrated learning approaches in online and face-to-face courses to explore their learning effects. These include peer feedback [3], [4], peer evaluation [5]–[7] , self-evaluation [8], problem-based learning [9], and also learning by example [10]. The aim of this research is to provide students with learning opportunities so that they are engaged throughout the entire assignment. This is accomplished by moving away from traditional assignments that are primarily directed by the instructor to a more collaborative approach where students become active participants at each stage of the assignment, where students are able to create their own problems based on a prompt created by the instructor, solve the problems created by others and then grade others' solutions based on a prompt created by the instructor.

Thus, the Participatory Learning (PL) main research objective is to foster deeper learning based on the learning objectives chosen by the instructor. Deeper learning relates to the search for knowledge to improve one's understanding rather than at a surface level in which the learner only focuses on memorizing as much information as possible to obtain passing grades [11]. I extend the Unified Theory of Acceptance and Use of Technology framework (UTAUT) by Venkatesh [12] and introduce the PL approach in courses to enhance assignments. The PL approach works particularly well in these active assignments by supporting the assignment-lifecycle throughout its stages (create problem, create solution, grade solution, etc.) so that students not only participate from solving someone else's problem but also have the chance to engage in higher order thinking activities according to the Bloom's taxonomy [1] , to not only create their own problems but also to grade other students' tasks [5]–[7]. Throughout the entire problem lifecycle, the PL framework allows students to provide feedback and act upon it through the inclusion of revisions at any stage of the problem.

One of my major contributions from the educational perspective is researching PL with course assignments. Several learning approaches incorporated into the PL approach have been researched individually in assignments, including peer feedback, peer grading and self-assessment for specific parts of assignments in addition to problem-based learning in which students come up with their own questions. But they have never been combined into a holistic approach that allows for the entire assignment lifecycle to be worked on at multiple stages by students in a course. As an instructor, while learning management systems support individual aspects of the PL approach, it is difficult and time consuming to implement the entire approach with the currently readily available tools. Therefore, having a system available that instructors can use to create and manage the PL assignments would allow them to implement these educational methods more easily.

One of my major contributions from the Information Systems (IS) perspective is expanding Wu, Hiltz and Bieber current educational extension to the Technology Acceptance Model [13] to include critical thinking and system use, providing a more complete overview of the multiple relationships in the model. In addition, adding new constructs to the model will help further evaluate relationships between how much the use of the PL approach will affect not only students' perceived learning but also how it would influence the students' critical thinking.

When combining both the IS and educational perspectives, what guides and motivates my work is designing a robust system design that will allow students to become more active and in charge of their own learning. At the same time, I aim that through my evaluation and further report of the effect of the PL approach in classrooms, instructors will be more willing to use this approach (and system) so that courses can be more engaging for students while not incurring additional work for instructors. In addition, all the experiences I collect from running the pilot and main study will serve to inform instructors of the benefits of the PL approach and aim to further improve any shortcomings found during our study so that it can improve in the future. This work should serve as the first complete holistic evaluation of the PL approach that can then be further refined in the future.

1.2.1 Summary of Approach and Research Contributions

All contributions listed in this section reflect the research I have chosen to pursue, and I am reporting in this dissertation. I do not include contributions made by Wu, Hiltz and Bieber, nor by other members of the PL research or development teams. It should be noted that this dissertation work is not primarily about system development but rather about the design, evaluation and testing of the PL approach. Therefore, while I will report system contributions, the system and contributions made are not the main focus of this study.

1.2.1.1. System Contribution. My initial contribution encompassed the initial design of the core PL system that served as the early pilot from which the current PL system later further extended. This included:

1. Front-end design of the screens needed for critical PL features including the dashboard and task page. I worked developing paper screens that then served as the first blueprint for the design of the main PL features including dashboard and task pages.
2. Protocol analysis (think out loud protocol) and usability testing of the early pilot using paper prototypes to understand issues on the early design and prototype to further improve the PL system usability.
3. Design of the core database tables needed to hold basic information. While the PL system has been updated iteratively to hold additional information needed to provide flexibility to assignments, during the design of the core features of the PL system, a set of core tables were also created which were used to hold critical information for the system and have since been built upon.

Contributions related to the current PL system:

1. Usability testing: The original study by Wu, Hiltz and Bieber [2] did not focus on the usability of the system as it did not develop a system to support the PL approach.
    - I worked on conducting and analyzing semi-structured interviews with students at the end of the semester throughout the pilot and main dissertation study. These findings have helped provide additional context to the research findings while also providing a lot of feedback on the current PL system that will guide recommendations for future design.
    - I administered usability testing surveys given to all students in the treatment sections that allow us to have a baseline to compare the current PL system to future improvements.
2. Recommendation for future design and areas of improvement derived from interviews with students, and a standardized usability testing survey.

It should be clearly noted that this dissertation is not primarily about system development so the implementation details that will be included are reduced to only the aspects which I actively worked upon. I will not include any programming or code repository as my contribution but instead add other aspects in which I have contributed to the development of the system. By further evaluating the system this will then lead to me giving recommendations for design improvements for future implementations.

1.2.1.2. Scientific Contribution. The following contributions reflect the primary focus of my experimental design and resulting analysis, which I report and reflect upon in this dissertation.

From the IS perspective. My research extends the model created by Wu, Hiltz and Bieber [2]. This is achieved through the inclusion of additional constructs to the original model. The new constructs are System Use and Critical Thinking. In addition, I have added an additional condition to include initial exploration of Microlearning tasks for assignments and its effect.

1. My research also retests the hypotheses in the model made in the earlier study by Wu, Hiltz and Bieber that extended TAM/UTAUT technology acceptance model for assignments (as opposed to the original exam focus) in multiple domains including management information systems, programming, humanities, math, and philosophy courses.
2. Another IS contribution of this dissertation will be the evaluation of the system to test the updated PL research model using the system and its effect on students perceived and actual learning and also enjoyment. It should be noted that this is not an analysis or evaluation on system performance.

From the educational perspective: The PL approach was implemented originally by Wu, Hiltz and Bieber [2] several years ago for examinations. However, this was coordinated in a manual fashion without a system that could easily facilitate the process. An important contribution to education will be the systematic evaluation of a system and guidance for instructors that they can use to implement that PL framework in their classes. While the system itself will be available for others to use, the system is not a direct contribution of this dissertation. However, the results that are derived from testing and evaluating the system can aid instructors in 1) deciding to use the system and 2) converting their curriculum to more easily include PL assignments. Therefore, the summary of my contribution to education through my work on the PL study includes:

1. The evaluation of the effect on learning in students after using the PL approach in STEM and non-STEM courses for assignments. These results can guide instructors at multiple levels of education in further implementing the PL approach in their courses.
2. The original Wu, Hiltz and Bieber [2] study did not have a "control" which were included in this study. This would allow to compare the students' motivation and learning.
3. Implementation of a new approach to evaluate thinking in collaboration with the instructors. This allowed me to evaluate differences in critical thinking between students who were participated in the PL approach and those who did not.
4. A set of recommendations that will facilitate the implementation of the PL approach in the classroom including best practices and student educational surveys used to collect data.
5. PL assignments examples that would serve as guidance on how to convert regular assignments to PL assignments.

1.3 Research Overview

Whereas Wu, Hiltz, and Bieber's research focused on exploring acceptance of Educational Technology (the system that supports the PL approach) in examinations though the development of the Wu, Hiltz and Bieber model [2], my research retests this model on assignments while further extending it to include measures of system use and critical thinking. In addition, I have included another condition, microlearning, in which the assignments were broken into smaller tasks to provide students with more frequent learning opportunities. Finally, I aim to understand if there are any significant differences in student enjoyment, perceived learning, and critical thinking as a consequence of participating in the PL approach when compared against a control section in the context of course assignments.

This research was conducted in two stages. In the first stage I conducted a pilot (preliminary) study to test the instruments but also formally evaluate the PL system throughout multiple semesters at both NJIT and at Fairleigh Dickinson University (FDU). This pilot study involved 18 total sections where 7 were control and 11 were treatment sections. This pilot study aimed at exploring all the research questions except for those that referred to microlearning. Students received surveys in both treatment and control sections in addition to a critical thinking question developed with the instructors. In the second stage I ran the dissertation study during two semesters. For the dissertation study, the pilot survey was broken into three surveys to allow for collection of repeated measures. The first survey included general demographic questions, the second and third survey shared questions to collect repeated measures of the constructs at the middle and end of study. Finally, I also conducted a small study using a 2 microlearning sections to further explore its effect in the students' perceived learning, enjoyment, and recommendations of the approach. Additional description of the methodology and results from the pilot and main dissertation study can be found in Chapter 6 and 7 respectively.

The following are my research questions about the PL approach, which serve as the backbone for the pilot study presented as part of my proposal, and the final dissertation study. It should be noted that while the PL approach is flexible enough to be able to be applied to assignments and examinations, I will be focusing primarily on assignments as this was not the focus in Wu, Hiltz, and Bieber's [2].

1. Main Research Question #1: How does the PL approach affect the students in the course when applied to assignments?

- Sub-question #1.1: Do students enjoy their learning experience in the Participatory Learning approach for assignments?

- Sub-question #1.2: Do students perceive learning in the Participatory Learning approach for assignments?

- Sub-question #1.3: Do students perceive learning from each aspect of the PL approach for assignments? (i.e., create problem, provide solution, grade others, viewing others' work)

- Sub-question #1.4: Would students recommend using the PL approach for their assignments?

2. Main Research Question #2: Do the hypotheses in the model used by Wu, Hiltz and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?

    - Sub-question #2.1: Do all hypotheses in the original model hold true for assignments?

    - Sub-question #2.2: How can I extend the Wu, Hiltz, and Bieber theoretical model to account for actual learning (critical thinking) and system use?

    - Sub-question #2.3: How does microlearning affect the model?

3. Main Research Question #3: Are there any significant differences in the effect in enjoyment, learning and critical thinking between students who experienced the PL approach and those who did not?

    - Sub-question #3.1: Are there any significant differences in perceived enjoyment between students who experienced and those who did not experience the PL approach?

    - Sub-question #3.2: Are there any significant differences in learning between students who experienced and those who did not experience the PL approach?

    - Sub-question #3.3: Do students who participate in the PL approach improve their critical thinking skills when compared to those who do not participate?

1.4 Dissertation Outline

This dissertation is organized as follows. Chapter 1 includes the background and motivation, and also presents an overview of this research study and my research questions. Chapter 2 presents a literature review of Bloom's Taxonomy, Peer Feedback and Assessment, Self-Assessment, Microlearning, and Motivation which are relevant to the educational value of the PL approach. Relevant literature regarding similar systems or the TAM/UTAUT models is provided in chapter 4 and 5 respectively. Chapter 3 presents an extended description of the PL approach. Chapter 4 describes the Participatory Learning system including a general overview, contrasts similar systems, presents the history of development, and describes its features. Chapter 5 describes the PL research model, data collection and instruments used. Chapter 6 presents an extensive preliminary (pilot) study that tested all our instruments and guided our main study. Chapter 7 presents the main dissertation study over the course of two semesters including descriptive statistics and quantitative and qualitative data analysis in addition to discussion of the results. Chapter 8 discusses limitations and contributions of this research and suggests avenues for future work.

CHAPTER 2

LITERATURE REVIEW

This research combined with technology will lay the foundation for a holistic approach known as the Participatory Learning (PL) approach. The foundation of the PL approach is guided by how students assimilate knowledge based on Bloom's taxonomy but also supported by learning theories and teaching practices (peer assessment, peer feedback, self-assessment) explained below. This chapter begins with current issues with assessment framed within the context of the Bloom's taxonomy theory. I then discuss individuals' motivation and student agency. Finally, I discuss traditional learning practices and a newer approach known as Microlearning. At the end, I present a summary of the literature findings.

2.1 Bloom's Taxonomy

Overall, students have often been graded through the use of assessments to measure their learning. However, research has also shown that assessment can serve as learning opportunity by offering formative feedback [14], [15]. However, it can play a double-edged sword if the assessment is inaccurate or if the students are assessed more than they should as it could affect their motivation towards learning. This is because students then switch their focus to become motivated to master the way they take exams rather than master their own learning [16].

On the other hand, if students become inaccurately assessed it could then send mixed signals to the students who thought they were learning but then are given feedback that says otherwise. Therefore, appropriate assessments not only maintain the motivation towards learning, but also accurately communicate to the students about their learning [17]. Benware and Deci argue that undergraduate students in a competitive setting have become used to learning material in order to pass exams and thus have become adept at memorizing what is necessary [16]. Whereas memorization of knowledge is an important precondition required for putting higher order cognitive skills and abilities into practice [1], overreliance on memorization for the singular purpose of just achieving grades could limit students learning.

In 1956, Bloom published a classification where he categorized several educational goals which became known as the Bloom Taxonomy. The original Bloom's Taxonomy included six categories ranging from Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Bloom's Taxonomy describes the following categories [1]:

1. Knowledge involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting.
2. Comprehension refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications."
3. Application refers to the use of abstractions in particular and concrete situations.
4. Analysis refers to the breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between ideas expressed are made explicit.
5. Synthesis refers to putting together of elements and parts so as to form a whole.
6. Evaluation refers to judgments about the value of material and methods for given purposes.

In 2001, a group of instructional researchers and cognitive psychologists published a revision to Bloom's Taxonomy and made several changes to the original classification. First, the revised taxonomy replaced the static nouns used in the original classification with verbs to label the newer categories. These verbs in fact represent the cognitive actions or processes that the learners go through when working with knowledge. Second, the revised taxonomy switched the two highest levels in the original Bloom's taxonomy. For Anderson, *creating* was considered higher level in the cognitive domain than *evaluating*. The Revised Bloom's Taxonomy is as follows [18]:

1. Remembering refers to retrieving, recognizing, and recalling relevant knowledge from long-term memory, e.g., find out, learn terms, facts, methods, procedures, concepts.

2. Understanding refers to constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. Understand uses and implications of terms, facts, methods, procedures, concepts.

3. Applying refers to carrying out or using a procedure through executing, or implementing. Make use of, apply practice theory, solve problems, use information in new situations.

4. Analyzing refers to breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing. Take concepts apart, break them down, analyze structure, recognize assumptions and poor logic, evaluate relevancy.

5. Evaluating refers to making judgments based on criteria and standards through checking and critiquing. Set standards, judge using standards, evidence, rubrics, accept or reject on basis of criteria.

6. Creating refers to putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Put things together; bring together various parts; write theme, present speech, plan experiment, put information together in a new & creative way.

In addition, in the revised taxonomy, Anderson created a separate classification for the different types of knowledge used in cognition. This knowledge dimension represents a range from concrete (factual) to more abstract (metacognitive) [18].

1. Factual Knowledge
    - Knowledge of terminology
    - Knowledge of specific details and elements
2. Conceptual Knowledge
    - Knowledge of classifications and categories
    - Knowledge of principles and generalizations
    - Knowledge of theories, models, and structures
3. Procedural Knowledge
    - Knowledge of subject-specific skills and algorithms
    - Knowledge of subject-specific techniques and methods
    - Knowledge of criteria for determining when to use appropriate procedures
4. Metacognitive Knowledge
    - Strategic Knowledge
    - Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge
    - Self-knowledge

Therefore, according to Bloom’s Taxonomy, memorizing course material would not necessarily lead to students engaging in higher order thinking as it falls in the low spectrum of cognition. We can thus argue that high grades are not representative of how adept students are at the higher cognitive levels of Bloom’s taxonomy [19].

The PL approach to course assignments, which is the focus of this research, not only provides new avenues for learning [19], but at the same time creates ways to move away from standard tests by offering a medium for students to not only be creative but also ways to assess student work throughout the problem lifecycle, which is different than regular standard tests. Research has shown that although there was a failure to find a strong correlation between grades and long-term retention of knowledge with respect to final examinations, Conway states that the course-work component of a grade reliably predicts very-long term retention of knowledge [19]. Thus, by applying the PL approach to assignments, we aim to not focus on how students use their knowledge on examinations but rather focus on the knowledge acquisition that happens throughout the completion of assignments throughout the course.

According to Bloom's taxonomy, through the PL approach, students are given not only the opportunity to apply knowledge they learn in class (remembering), they are also given the opportunity to compare different bodies of information presented and explain instructions needed to accomplish some tasks (understanding). In addition, students also get the chance to implement their knowledge to arrive to a solution (applying) and differentiate between two bodies of information (analyze). However, the most important aspect of the PL approach is its focus on peer feedback and critique (evaluating) and also the generation of new problems to give to other students (creating). Therefore, throughout the PL approach, the students are challenged to engage not only in lower but also higher order cognitive processes.

Additionally, research has shown that students who practice and work out problems tend to do better on their final assessment than those who simply review notes despite the individuals' class standing [20]. Given the benefits of practice with regards to preparing better towards their final assessments, the PL provides plenty of opportunities for students to work out topics throughout the entire assignment lifecycle while also adding unique opportunities for the students to reflect on their work by giving and receiving feedback.

2.2 Traditional Learning

Traditional learning has taken place in the classroom (either physically or virtually) through which the instructor has been seen as the disseminator of information through which knowledge is transferred from the instructor to the student. Traditional classrooms activities involve class recitations given by the instructor, reading of material frequently assigned in between lectures, and a certain number of examinations given to students through written (quizzes, exams), verbal (oral presentations) or a combination of both types of examinations through which the instructor assesses their students' learning. However, there has been a shift in the way learning is characterized by taking place beyond the teacher-driven knowledge transmission to a more active process where students' knowledge becomes actively constructed by them [21]. Nevertheless, despite the inroads made to change the way teaching occurs in the classroom, traditional lecture and textbook methodologies continue to dominate mathematics and science in middle schools in the United States [22].

In a study by Smith conducted at an elementary school in Chicago, Illinois based on a student sample of 110,775 subjects and 5,586 surveyed teachers from 384 schools, it was found that the instructional approach they used influenced how much students learned in reading and mathematics. In addition, interactive teaching methods were associated with more learning. For the purpose of the study, a didactic approach is described as traditional, instructor-centered, highly structured or didactic instruction. On the other hand, an interactive approach is shown as student-centered or constructivist instruction. In a didactic approach, as described by Smith, the instructor usually 1) lectures or demonstrates to students, 2) poses questions for single-short answers, 3) assesses students on correctness and 4) determines what the students will study. On the student side, they usually 1) listen to the teacher and recite answers, 2) try to repeat the knowledge being taught, and 3) rarely choose what topics to study. On the other hand, in an interactive approach the instructors usually 1) coach, listen and guide students, 2) pose questions about asking for explanations, 3) assess how students arrive to an answer and 4) provide choices over what students should study. On the student's side, they usually 1) discuss answers and ideas with instructors and peers, (2) apply, interpret and integrate knowledge into prior understanding, and 3) frequently choose what questions or topic to study. [23]

Nevertheless, student learning and higher achievement should not only be focused on the teaching methods used in the classroom, we should also argue that the kinds of assignments students are given affect their overall learning. For example, in a study by Newman on Chicago's teacher assignments in mathematics and writing in grades 3,6, and 8, it was shown that students who received more intellectually challenging assignments also achieved above average gains on the Iowa Test of Basic Skills in reading and mathematics and also demonstrated higher performance in reading, mathematics and writing on the Illinois goal assessment programs [24]. Newmann introduces the concept of 'authentic' intellectual work and describes it as construction of knowledge, through the use of disciplined inquiry, to produce discourse or performances that have value beyond school. Newmann describes the construction of knowledge as the building of knowledge needed to solve a problem that cannot be solved through the routine use of information or skills previously learned. In doing so, one engages in organizing, interpreting, evaluating, and synthetizing prior knowledge to solve a new problem. Still, constructing new knowledge is not simply enough as it must be guided by disciplinary inquiry through which one 1) uses a prior knowledge base, 2) strives for in-depth understanding rather than superficial awareness and 3) expresses the ideas and findings through an elaborated communication. Finally, the third criterion signifies that intellectual accomplishments have utilitarian or personal value beyond school and uses examples such as quizzes and final exams to provide a contrast as having little value beyond school because they are designed to document the competence of the learner [24]. Therefore, there is indeed a demand for graduates that possess a greater range of skills that includes effective communication beyond their area of specialization. Thus, courses in that school district are now required to develop transferable skills, key competencies, generic attributes or capabilities to cultivate better rounded individuals [25].

Beyond the coursework given in classrooms, students' interactions with one another have also become an important aspect in modern instructional practices. It has been argued that knowledge is constructed and shared through our social interactions. Thus, learning in a social context can be studied through our understanding of Social Constructivism. Vygostky's work forms the foundations of social constructivism in education where he emphasizes the role of the greater community and the role of significant others in learning. From a Social Constructivist perspective, learning is an active process involving others. The influence of constructivism in education can be seen in a variety of published curricula and instructional practices through the widespread use of cooperative and collaborative strategies such as peer-peer tutoring, team-games tournament, etc. The emphasis is on having students work together while sharing ideas and challenging each other's perspectives [26].

In this sense, through the implementation of the PL approach we aim to engage students intellectually and have them become active participants in the construction of their learning. Through the PL approach we encourage students to engage with others in constant dialogue through which they feed each other information not only through assignment instructions but also by providing solutions to others, grading their peers' work, and feedback sharing. Therefore, the PL framework is collaborative to the extent that students are participating with and guiding their peers through the interactions between the stages of the problem lifecycle. In addition, since the initial instructions of PL assignments are very open-ended, students are encouraged to engage in the construction of knowledge by creating their own set of questions and instructions that others must solve. Thus, to create a question for others, students not only synthetize information learned in class but also draw from their own experiences which are then conveyed in a final product.

2.3 Feedback and Assessment

Feedback allows students to strengthen their capacity to regulate their own performance. According to Nicol and Macfarlane-Dick, good feedback practice (1) helps clarify what good performance is (goals, criteria, expected standards); (2) facilitates the development of self-assessment (reflection) in learning; (3) delivers high quality information to students about their learning; (4) encourages teacher and peer dialogue around learning; (5) encourages positive motivational beliefs and self-esteem; (6) provides opportunities to close the gap between current and desired performance; and (7) provides information to teachers that can be used to help shape the teaching [27].

According to Black, feedback given as rewards or grades enhances ego involvement rather than task involvement [6]. That is, students use the feedback as a way of comparing themselves to others. However, those who only receive comments see it as someone trying to help them improve. In addition, feedback that focuses on what needs to be done and that is more constructive tends to encourage students to believe that they can improve. In turn, this leads to an enhancement in learning by motivating students to invest their effort into their learning [6].

2.3.1 Peer Feedback and Peer Assessment Definition

Peer feedback and peer assessment have been well studied for their effect in team and work group effectiveness which affect team performance. In addition, peer feedback plays an important role in enhancing student learning in a collaborative setting [28]. Several meta-analysis studies have demonstrated that feedback plays an important role in student achievement and emphasize the role that feedback has when compared to other aspects of teaching [3], [4].

Unfortunately, as class size grows, it then becomes increasingly difficult for instructors to provide feedback to all students without it having an effect on their workload. However, as class size continues to increase, so do the assessment costs. As a consequence, assessment costs could overtake teaching costs as instructors find themselves spending much of their time marking [29] and providing feedback. Peer assessment is valuable in placing the work in the hands of students and thus freeing the instructor to observe and reflect on what is happening in the classroom and frame helpful interventions. [6] In a study by Maclellan, a majority of instructors considered feedback to be helpful in its detail (93%)

and to improve learning (94%). However, while students also considered feedback valuable, it was to a lesser degree than what instructors claimed [30].

Peer feedback is defined as a communication process through which learners enter into dialogue related to performance and standards [31]. On the other hand, *Peer assessment* is defined as students grading the work or performance of their peers using relevant criteria [31]. Falchikov defines peer assessment as the process through which groups of individuals rate their peers. This process may involve the use of rating instruments or a checklist which may be designed by others before the peer assessment exercise, or be designed by the user group to meet their particular needs [32]. Peer assessment may be used to assess products such as written work but quite often is used to assess the performance of peers [32]. Examples of applications of peer assessment to evaluate performance apply to its use in the classroom [5]–[7] , medical field [33]–[35], and group performance context [36].

The distinction between peer feedback and peer assessment focuses on the degree of detailed comments incorporated in peer feedback but without the grading or 'assessment' part involved [31]. Through the involvement of students in the peer feedback process, they become actively engaged in articulating their own understanding on a subject matter. In addition, the timing and amount of feedback received from peers is faster and in larger amount than academics when providing comments [31], [37].

An important aspect of peer feedback and assessment lies in the fact that they are intimately linked [6] as there is an overlap in the skills required for peer and self-assessment which would help students to better assess themselves [31]. According to Black, peer assessment turns out to be an important complement to self-assessment because students may end up taking criticism from one another that they would not have considered had it been brought up by an instructor. Both peer feedback and assessment become valuable because the interchange will be in a language that students themselves use naturally in which they take over the role of instructors. Thus, the importance of peer feedback and assessment is on how it forces students to challenge their assumptions to help them be critical about the quality of arguments, which is essential for work that does not necessarily have a defined answer. In addition, whereas students who give feedback as marks are likely to see it as a way to compare themselves with others, students who give feedback through comments see it as a way to help others to improve. Also, individuals that give feedback tend to outperform others that solely rely on giving marks [6].

When applied to the PL approach, peer assessment and peer feedback are an important aspect due to how each task is done by students. At each stage of the assignment process, the PL approach allows students the opportunity to provide feedback. For example, questions created by students can be reviewed by others who then provide feedback. In addition, students can grade the questions created by others so that their grade is not calculated based on the quality of the solutions they provide but also the quality of the questions they create. At each stage in the assignment, there is the potential for students to provide feedback and assessment to others.

2.3.2 Peer Assessment Validity

There have been several studies that have noted the high agreement between instructor and peer-based assessments. For example, In the case of oral presentations, high agreement between student and instructor ratings was found in several studies [38], [39]. In a study by Hughes and Large there was agreement found between staff and peers about the relative quality achieved in the presentations done by the students [38]. In a study by Freeman in which students assessed their peers' presentation quality using a 22-point guide to evaluate their content and presentation, it was found that there was not significant difference between student and staff averages although the correlations between them were only moderate. However, it should also be noted that the grades had a higher agreement during the second half of the semester [39].

2.4 Self-Assessment

In addition to peer assessment and feedback, self-assessment plays an important role in enhancing learning opportunities for students. According to Klenowski, self-assessment is "the evaluation or judgment of 'the worth' of one's performance and the identification of one's strengths and weaknesses with a view to improving one's learning outcomes" [40]. However, as Ross describes, the benefit of self-assessment is more likely derived from its use within the scope of three preconditions such as student-teacher negotiation over self-assessment criteria, teacher and student dialogue focus on evidence for judgement, and that self-assessment leads to a grade [41]. Self-assessment is an important aspect of the PL approach which helps twofold: 1) it provides an additional learning opportunity for students and 2) it helps provide another degree of control to students with relation to their grades because to dispute a grade the PL approach requires the student to grade themselves and reflect on their own work.

2.4.1 Self-Assessment Reliability, Validity and Performance

There is some mixed reception for self-assessment reliability with respect to its internal consistency. Several researchers such as Ross and Rolheiser found high internal consistency in a study on 5^{th} and 6^{th} grade students. The study results indicated an alpha of 0.91 on six measured items that used a 1-10 scale in which students rated their own performance in mathematics [42]. The high alpha indicates high internal consistency across the six items measured. Another study by Ross and Rolheiser on 4^{th} to 6^{th} graders showed a 0.84 alpha for internal consistency for self-assessment in English [43]. In another study of around 300 medical students by Fitzgerald, it was shown that the self-assessment scores across cognitive (analyzing test results) and performance tasks (patient examinations) were consistent and that students were fairly accurate in estimating their performance against objective standards [8].

However, there are mixed results when evaluating reliability for self-assessment measures across different periods of time with shorter time frames across self-assessment measures yielding better reliability. For example, a study by Sung on 76 3^{rd} graders divided across two classes demonstrated that student self-assessment measures on web-page designs were consistent over time. In the study, self-ratings were collected in three stages: 1) before viewing others' work, 2) during group discussion and 3) after viewing others' work. The results showed no significant differences between each stage. Nevertheless, there was a significant difference before and after viewing others' work ($p=0.056$) [44]. On the other hand, in a longitudinal study by Blatchford on students from ages 7 to 16 years on mathematics and English reading, it was found that the consistency of self-assessments was not great in either subject on the ages of 7 and 11 and that between the ages of 11 and 16 the self-assessment scores were more reliable in mathematics [45].

In addition, the validity of self-assessment is another important point of consideration and for the purpose of the study we will refer to how well the self-assessment measures match an instructor or a subject-expert measure. Studies have shown mixed results across different student populations ranging from high-school and a college student population. A meta study by Boud and Falchikov found a certain degree of agreement between self-assessment and instructors' grades. Still, there were some issues such as concerns about the fact that the concept of 'agreement' between students and instructor was not clearly specified, or that the criteria for self-assessment was not defined in addition to the shared criteria used to compare ratings between instructor and students [46]. In a follow up meta-study by Falchikov and Boud, it was mentioned that improved agreement between self- and instructor grades was based on the following: 1) higher quality designed studies found greater correspondence, 2) the level of the course played an important factor as students in advanced courses appeared to be better at assessing than those in introductory courses, and 3) the domain of study appeared to produce more accurate assessment with those within the area of science appearing to produce more accurate assessments.

On the other hand, students have shown in other studies that generally their self-assessment grade is often higher than grades given by instructors due to multiple reasons including 1) overestimation of self-assessment due to the lack of cognitive skills to evaluate their own ability [41] and 2) the course final grade including the measure of their self-assessment which can greatly affect it [46]. However, other studies have shown that students' self-assessment tended to have closer agreement to an instructor's grade when the 1) self-assessed grade would had been compared with another grader such as another student or the instructor [47], and 2) when students have been trained on how to assess their own body of work [43], [44].

An argument can be made about the consequential validity of a test as determined by its consequences to students in which the act of assessing themselves would have some contribution to the student learning. Therefore, we can argue that a test that negatively affects that learning of a student would be rendered not valid. Moss argues that the adverse consequences undermine the validity of an assessment only if they can be traced to a problem between the fit and the construct [48]. Below I suggest then several aspects in which self- assessment would affect student learning directly or indirectly.

It has been argued in several studies that students who engage in self-assessment have shown increased measures of achievement, self-efficacy and intrinsic motivation. In a study on continued motivation by Hughes, Sullivan and Lou on 250 5th graders who engaged in either teacher or self-evaluations across two difficulty levels, it was shown that 14% more subjects returned to work on the hard task rather than the easy task when engaging in self-evaluation [49]. In a study by Schunk, it was shown that having students assess their capabilities in learning helps them understand that they have become more competent; in turn this perception would then fuel their own perception on self-efficacy and thus helps them keep working productively. However, it was also noted that it is important to help students make accurate self-assessment as low self-evaluations can slow motivation despite the fact that the student could be making progress [50].

In a study by Fontana and Fernandez that aimed to test the effect on children's academic performance based on the use of self-assessment techniques, twenty-five teachers were trained in a 40-hour course on self-assessment techniques which they later introduced into their classes. The study included 354 students in the test group and compared the results to a control group of 313 children where self-assessment was not included. It was found that self-assessment helped provide increased achievement benefits for students from the ages 8 to 14 in their math class [51].

In several studies conducted by Ross, various strategies were applied to teach self-assessment in four stages: 1) have the students be involved in the creation of the assessment criterion with the help of the instructor so that the criterion is framed in a way that the language is meaningful for the students, 2) train students on how to implement the criteria outlined, 3) engage students so that they can reflect and discuss any differences in self, peer and teacher assessment, and 4) help students use their self-assessment information in a meaningful actionable plan to form strategies to improve on their weaknesses [41].

Therefore, in terms of reliability, studies have shown great consistency across self-assessment measures taken over a small period of time across different subjects and tasks. In addition, whereas the validity of self-assessment produced mixed results, self-assessment can be a valuable learning activity even in the absence of significant agreement between student and teacher and can provide feedback to students related to learning, educational, and professional standards [52]. To conclude, self-assessment may be regarded as an acquired skill and as such needs to be developed [52]. With respect to the PL approach, there are opportunities for students to engage in self-assessment when disputing their grade and as such it is another important aspect of the PL approach.

2.5 Microlearning

Microlearning (ML) is a relatively new concept. As such, there is discord about the definition of what microlearning is. Whether "microlearning" is defined in terms of the content, processes, or technology of competencies of the learning groups – it is important to remember that the learning occurs at the smaller levels so minutes and seconds become more relevant rather than hours or days. A second context for microlearning refers to the term of "knowledge economies" that reflects the reality of the fragmentation of source and units used for learning [53]. According to Korachev and Cao, microlearning refers originally to a learning activity that takes place on small pieces of knowledge on web-based resources. They make a distinction between microlearning and microblogging in the fact that the latter is more about disseminating information to others while the former is about collecting personally relevant information from multiple sources and using this information to close some knowledge gap [54].

Microlearning provides a way to deliver content through short and small interactions with the students so as to reduce information overload. As the information overload becomes smaller, the ability for students to retain information and content is enhanced. According to Bruck, the idea behind microlearning is that content is broken down into smaller digestible parts in which learning takes place at a constant pace through small steps, which better fits the human processor model of attaining knowledge in smaller homogeneous steps [55]. At the same time, breaking down the content to be delivered to the students into smaller tasks opens up the opportunity for the learning to take place through a wide array of devices including mobiles since the content can then be better designed to display and fit smaller mobile screens. Thus, microlearning provides the opportunity for mobile-learning to better fit and complement multiple forms of learning [55]. There have been several implementation studies that support this idea [56]–[59]. For the PL approach, incorporating microlearning and microcontent will serve as a guiding principle that will allow us to provide an alternative to the regular PL approach, in which the tasks can be broken into smaller chunks of information so that students are able to focus on specific aspects of each task (microtask) and receive more timely feedback when needed. For example, rather than waiting for two weeks for a task to be submitted to then receive feedback, through the use of microtasks students could have parts of their work reviewed before they finish a main assignment task (e.g., create problem, solve problem, grading). In addition, for large assignments with long tasks, turning these tasks into microtasks could potentially help students complete them by focusing the students on specific parts of the tasks while also reducing the overall task complexity.

2.6 Motivation

Motivation has been an important aspect studied in human psychology which deals with the different reasons that push people to act according to different factors in order to achieve an objective [60]. People can be motivated due to them valuing the activity itself or due to external coercion. In turn, these present stark contrasts as some individuals become internally motivated while others are externally pressured. [61] In this section, I explore the different views on motivation from different theoretical perspectives.

In relation to the PL approach, motivation is an important aspect of students' perceived enjoyment which will ultimately influence students' recommendation of the approach and also help engage them in the process. It will be important for us to determine if the PL approach affects students negatively by increasing their frustration or positively by empowering students to take charge of their own assignments. Motivation is thus an important aspect of the PL approach to coursework as it aims to have students focus on all aspects of the assignment by allowing opportunities for formative assessment rather than having students focusing solely on the grading aspect. Thus, rather than focusing on an extrinsic motivator such as grades, it aims to shift the focus towards the actual assignment process to intrinsically motivate students on all of its aspects.

2.6.1 Self- Determination Theory

According to Ryan, to be motivated is to be moved to do something [60]. Whereas most contemporary motivational theories have treated motivation as a unit that differs in amount but not type, Self-Determination Theory (SDT) instead focuses on differentiating types of motivations to make predictions about performance and psychological-health outcomes [62]. SDT is an approach to human motivation and personality that uses traditional empirical methods while employing an organismic metatheory that highlights the importance of humans' evolved inner resources for personality development and behavioral regulation [61]. Motivation can also be classified into intrinsic and extrinsic motivation [63]. In SDT, autonomous motivation encompasses intrinsic motivation and well-internalized extrinsic motivation. In turn, controlled motivation encompasses regulation by external factors such as external rewards and punishment or by internalized contingencies such as ego involvement [62].

2.6.2 Intrinsic Motivation

According to Ryan, Intrinsic motivation is an important aspect for educators, which can be systemically catalyzed or undermined by parent and teaching practices. Intrinsic motivation results in enhanced quality learning and increased creativity [60]. Intrinsically motivated individuals engage in an activity for the satisfaction derived from the activity itself rather than other apparent reward [64]. Thus, individuals who are intrinsically motivated engage in an activity for the challenge or enjoyment of the activity itself rather than rewards or other external pressures [60].

According to Ryan and Deci, intrinsic motivation exists within each person but also as a link between individuals and activities. Intrinsic motivation can be operationalized in many ways. For example, according to Skinner's operant theory, intrinsically motivated activities are rewarding on their own. However, intrinsically motivated activities can also be those that satisfy inner psychology needs. Ryan in turn focuses on how intrinsic motivation satisfies competence, autonomy, and relatedness [60].

2.6.3 Measuring Intrinsic Motivation

There are different ways intrinsic motivation has been operationalized. According to Deci's 'free-choice' behavioural measure [64], individuals are given a task to work on and then left alone to decide what to do next. Thus, individuals are given the choice to either engage on the same task or engage on something else. Other measures is through individuals reporting their enjoyment on the activity itself [60], [65]

2.6.4 Improving Intrinsic Motivation

As stated by Benware and Deci, as the goal of most educations is promote conceptual learning, procedures that facilitate intrinsically motivated learning would seem of central importance [16]. Deci and Ryan proposed Cognitive Evaluation Theory (CET), which aims to determine the factors in a social context that produce changes in the levels of intrinsic motivations. That is, interpersonal elements and structures like rewards or feedback that promote feelings of competence further strengthen intrinsic motivation for the task at hand due to it fulfilling the psychological need for competence [60]. However, the feeling of competence needs to be accompanied by a sense of autonomy (internal perceived focus of causality) and according to Deci, positive feedback has been shown to increase motivation on individuals [60]. Grolnick, Deci and Ryan state that supporting the autonomy in children should be tied to encouraging them to be self-initiating and volitional in their actions. Therefore, it is important to provide the support necessary for children to feel ownership in their actions as if the action originated from within them [66] and thus provide individuals with more agency over their actions. In the case of the PL approach, students will evaluate each other while also providing feedback. While cognitive feedback will be important to help the reviewee improve their work, positive affective feedback will be as important to improve student enjoyment in the process and further intrinsically motivate them.

2.6.5 Weakening Intrinsic Motivation

Research has shown that extrinsic rewards could lower intrinsic motivation [60]. In a study by Lepper and Greene, children who had shown intrinsic interest towards an activity demonstrated less subsequent intrinsic interest after engaging in that activity with an extrinsic goal in mind as there were negative effects when an award was promised that manifested through performance and interest [67]. Similarly, in a study by Harackievicz, it was shown that performance-contingent rewards were found to undermine intrinsic motivation more than task-continent rewards. Harackievicz found that regardless of any kind of reward a subject gets, positive feedback enhanced the subjects' intrinsic motivation [68]. Rewards can therefore switch the focus of the activity from being intrinsically motivated to being motivated by external factors [60] and thus directly affecting the individual engaging in the activity [64].

In addition, performance feedback has shown that it actually ends up diminishing intrinsic motivation as shown in a study by Deci and Cascio. In the study, subjects were asked to solve puzzles and then observations about the relevancy to their intrinsic motivation were made. In the treatment condition, subjects were given more difficult puzzles so that they failed more than the control group. Students in the treatment group showed less intrinsic motivation after they were done with solving their puzzles than the subjects in the control group. Another experiment included a negative buzzer that rang every time a subject in the 'threat' condition failed to solve a puzzle, while those in the control did not receive a buzzer. The results showed that those who received the buzzer ended up having lower intrinsic motivation [69].

2.6.6 Extrinsic Motivation

According to Deci [60], extrinsic motivation refers to the realization of an activity under the premise that a separate external outcome occurs. A student thus could do coursework due to fear of being punished by the parents but also due to the belief in the activity being of utility. Therefore, there are multiple external motivations including fear of punishment but also personal choice to engage in an activity due to its perceived value [60]. In the case of the PL approach, it will be important to clearly explain students the benefit of the actively participating in PL so that it can also serve as motivation to students who buy into the process.

2.6.7 Attributional Perspective

From an attributional perspective, Weiner argues that people try to understand themselves and their environment, and act upon this knowledge. Upon an event happening such as failing or succeeding at an exam, the student engages in a behavioral reaction in which the motivational process is guided by the attributional inferences between the stimulus (exam) and response (reaction to the outcome). The affective reaction to the outcome could be happiness due to attaining the goal or unhappiness due to not fulfilling the goal. These general affective reactions are not mediated by much cognitive work. Afterwards, individuals ask themselves the reasons behind the outcome. However, due to cognitive limits, individuals do not often reflect upon every event but more likely seek reflection when an event is unexpected or negative. In addition, when seeking causes, one is more likely to take credit for success than blame failure on oneself [70].

2.7 Summary

The research for this dissertation integrates insights from the field of cognition and educational learning theories to sustain the PL approach. This approach is a combination of educational theories into a holistic perspective to assignments that seeks to provide learning opportunities for students without increasing work to instructors. There are two foundational aspects that this research incorporates. The first foundation of the PL approach lies on the learning theories that are based primarily on peer feedback and assessment in addition to aiming to engage students into the highest levels of cognition in the Bloom's taxonomy pyramid where students create bodies of information. In the case of the PL approach, the latter is done through the creation of questions for other students. This chapter does not include literature on similar systems because that is covered in Chapter 3. However, it should be noted that although there have been similar systems proposed, there is not a system that facilitates work on all aspects of the coursework assignments as envisioned by the PL approach. The second foundation of the PL approach is based on the motivational aspect that allows students to take charge of their own coursework, which in turn gives them agency towards their own learning experience. In the following chapter, I will explain the PL system (website) features that support the PL approach and that facilitates the logistics involved in managing the PL assignments from conception through completion including several stages of question creation, solving, peer feedback, peer grading and self- assessment.

CHAPTER 3

PARTICIPATORY LEARNING APPROACH

This research aims to test a new holistic approach to assignments where students are involved at each stage of the assignment process from creation to solving to grading of the entire assignment. This chapter presents an overview of the Participatory Learning (PL) approach with a focus on the multiple types of assignments that the PL approach supports that guided the design and development of the online web-based PL system needed to support the creation and management of assignments. The design is further explained in Chapter 5.

3.1 Participatory Learning Approach Overview

The Participatory Learning (PL) approach is a flexible framework that combines a series of teaching practices that include peer assessment, peer feedback, and self-assessment at its core. However, it also provides students with the opportunity to engage in higher-order learning by offering an avenue for them to engage creatively in the creation of problems to be given to their peers. In addition, it provides students with the opportunity to reflect on their work and modify it according to their own reflection or other students' feedback. While promoting additional learning opportunities, the PL approach seeks to not increase the amount of work by instructors unless they desire to actively participate in the process. Instructors have the option to also be involved as part of the process such as by providing additional quality control as part of the process through the direct assessment in any step in the assignment. However, the quality control steps can also be handled by students and as such it would not necessarily add work to instructors.

Since the PL approach is very flexible, there is an unlimited number of assignment schemas that can be created and tailored to fit the needs of the instructors. I define an assignment schema as the steps needed to be finished in order to complete the assignment. These steps include a combination of the following:

1. Problem creation refers to the act of creating a question to ask another student. This could be done by a single individual or could be built collaboratively through a series of smaller sequential tasks given to different students where a problem is built in stages. Through the creation of problems and questions, students engage in deeper learning through questioning [71], [72]. In fact, research has shown that students can develop critical thinking skills through questioning [73], [74]..

    - E.g.,: An ethics question could have student A create a simple ethical scenario outline and student B build upon the outline and provide a more specific ethical dilemma.

2. Problem solving refers to the act of providing a solution to a problem or question given. This step can be done by a single individual, it could be done by different students where they each could answer a part of the problem, or the solution could be built upon sequentially by different students. Through the solving of problems created by other students, students engage in learning in a similar manner to how they would learn from doing problems created by an instructor.

    - E.g.,: An answer to an ethics question could be solved by multiple students thus allowing students in the class so solve a varied array to questions.

3. Grading refers to the act of providing a numeric assessment based on the work done by another student. This can be done by a single individual or multiple students in which each grade is compared against another in order to determine the final grade for the task. Not only could solutions be graded, but the quality of a problem or feedback created could be assessed as well. Therefore, students would engage in peer feedback [3], [4] and peer assessment [5]–[7], and thus learn from participating in the activity.

    - E.g.,: Three different students can each provide their own grades and comments to a solution. Each grade could then be compared to the others and a final grade could be calculated.

    - E.g.,: A student problem (not the solution to the problem) could be graded by another student(s) so that they not only learn from creating their own problem but also from assessing the quality of a different problem.

    - Self-assessment refers to the act of engaging in the evaluation of one's work. In the PL approach, students have the opportunity to dispute their grade by evaluating their assignment themselves. Literature has shown that engaging in self-assessment provides opportunities for learning [8]

In addition, the PL approach allows students to learn by example by allowing students to view others work as specified by the instructor. By viewing others work, students can use it to guide their own work based on other students' perspective.

3.1.1 Sample Assignment Schemas

The PL approach allows for the creation of complex assignments that could be tailored to the needs of each instructor so that it can better fit their learning objectives. Some instructors like to provide students with additional opportunities to give each other feedback while other instructors like their students to work with each other iteratively to create better problems for peers. Below I provide examples of different schemas that the PL approach supports.

In the first schema "A" presented (Figure 3.1), we have three students participating in the PL assignment. Student #1 (s1) is the person creating the problem, Student #2 (s2) is the person in charge of solving the problem created by the previous student. After the solution is created, then Student #1 who was the one who originally created the problem and Student #3 (s3) who has not yet participated in the process are in charge of grading the solution. Having two graders gives a chance to the student who solved a problem to have his or her work assessed twice. If the grades match or are very close to each other (depending on the criteria set by the instructor), then Student #2 would receive the maximum, minimum, or average of the grades. However, if the grades do not match with a large grade disparity between the two graders, then Student #2 gets an option to dispute his or her grade.

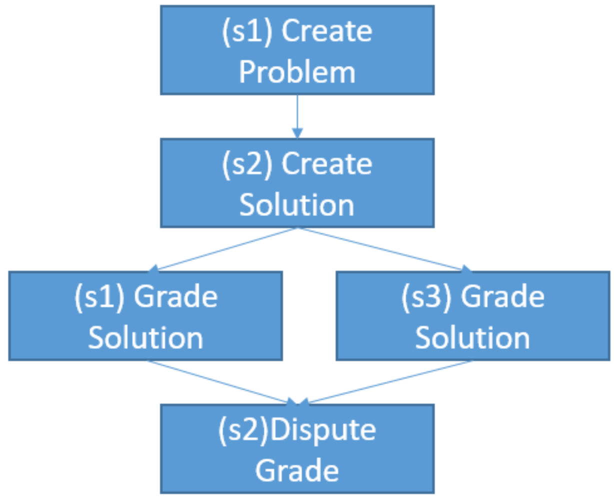


Figure 3.1 PL assignment schema "A."

In the following schema "B" (Figure 3.2), we present a modified schema "A" in which we added the ability for another student to review the quality of a problem created in order to ensure the quality of the problems given to other students. This step loops through s1 (problem creator) and s2 (problem reviewer) until the reviewer approves the problem that is then sent to s3 to solve. Another modification is that the grades are also assessed by s4 so that the first set of graders are then graded by others. As s1 and s2' grades are assessed by s4, s3 is able to dispute his or her grade if desired.

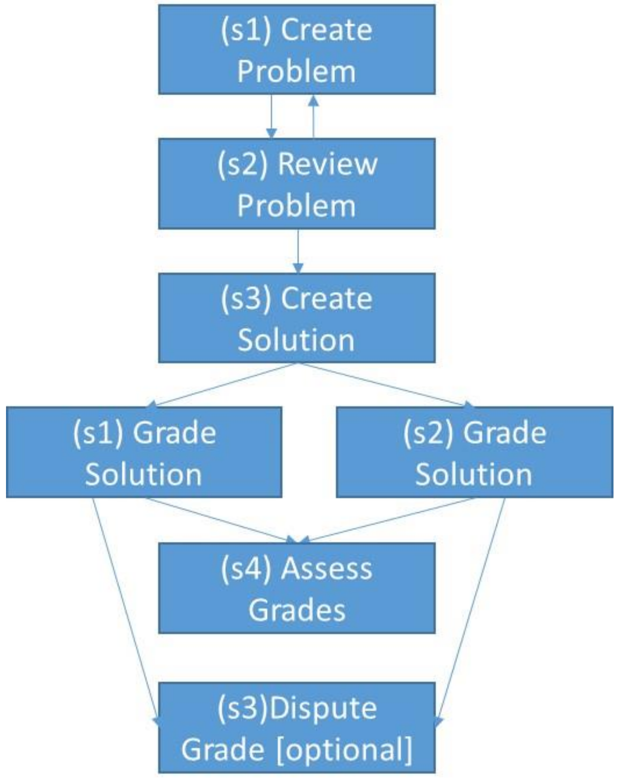


Figure 3.2 PL assignment schema "B."

In the following schema "C" (Figure 3.3), we present an assignment schema used in one of our courses. In this assignment, s1 is asked to create a spreadsheet to track a company's inventory while also providing a set of instructions for another student to work on. These instructions contained specific tasks needed to manage the company inventory per quarter for a whole year. Before the spreadsheet and instructions were sent to another student, the instructor (Instructor I) reviewed it to ensure that the spreadsheet created was of high quality and the instructions clear. If the instructor found issues with the student-generated spreadsheet, it was then sent back to the student for modifications. Once the spreadsheet was approved by the instructor, student s2 received it so that he or she could solve the spreadsheet according to the instructions provided the by spreadsheet creator. Once the spreadsheet was finished, it was sent to s1 who created the spreadsheet and s3 for grading. There was an optional grade consolidation stage that was triggered automatically when there was a significant difference between the two graders. This consolidation stage was done by s4. Finally, the s2 who solved the spreadsheet received his or her grade and had the option to dispute it if desired.

It should be noted that there is a slight but important difference between schema B and C which related to the review stage which was done by the students in schema B and by the instructor in schema C. This slight change provides an example on the need for flexibility in this approach because there are some assignments in which the instructor deems it necessary to be directly involved whereas in other cases peer collaboration is more valuable for the assignment learning outcome.

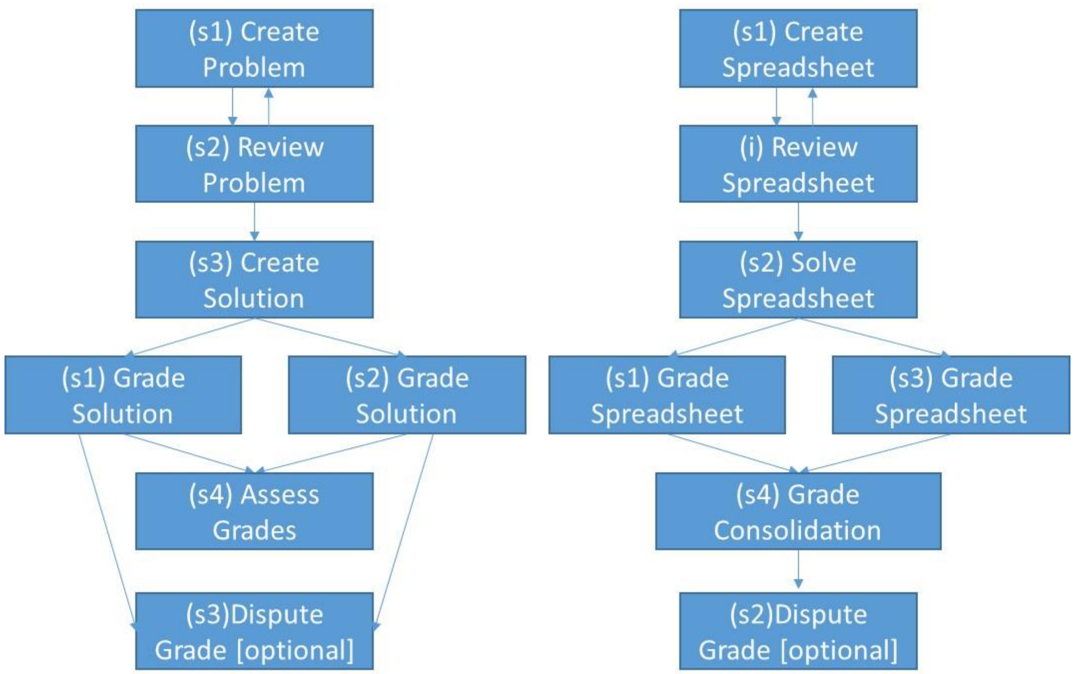


Figure 3.3 PL assignment schema “B” (left) and schema “C” right.

3.2 Summary

The Participatory Learning (PL) approach is a flexible framework that combines a series of teaching practices that include peer assessment, peer feedback, and self-assessment. In this chapter, I presented an overview of the different assignment schemas that the PL approach supports. However, it should be noted that the PL approach is flexible to adapt to the needs of the instructor. As such, a flexible system that supports this approach is needed in order to manage the entire process. In Chapter 4, I will present the PL system (website) that supports this approach including the features presented in the current version used for the preliminary and main dissertation study and also provide an overview of similar systems and their limitations.

CHAPTER 4

PARTICIPATORY LEARNING SYSTEM

This research primarily aims extend and test/evaluate the PL approach to course assignments and to evaluate the system that supports it. Thus, as part of this research, I have worked on the design and development of the PL system (website) that will support the PL approach. The system developed aims to support multiple teaching methodologies including peer assessment, peer feedback and self- assessment at every step of the assignment process by allowing the creation of complex assignments that can meet the instructors' requirements. In addition, the PL system facilitates the management of the PL approach in an effort to avoid incurring additional work for the instructors beyond the initial assignment setup. This chapter presents an overview of the PL system (website) including an overview of similar systems, the PL system history and the features included in the current PL system that was used to run the preliminary and main dissertation studies.

4.1 PL System

4.1.1 PL System History

Originally, the Participatory Learning (PL) approach was tested both locally at NJIT and abroad. This early study was only conducted on examinations at a university level. This initial study was conducted using an already developed course management system. While the system used was able to manage the examination process and serve the needs of the study, it was not able to provide a fully customizable experience that could meet the needs of a more complex examination or assignment process. Years later, thanks to the support of NJIT's Summer Undergraduate Research and the McNair Achievement program, I have worked as part of the original PL development team and directly contributed to the development of the initial design and prototype that has served as the original PL implementation which was then tested in the subsequent years.

The purpose of the Participatory Learning (PL) system I worked on has been to streamline the logistics required for management of complex peer-driven assignments (and also examinations), from the beginning including the question creation until the end which includes the grading and grade dispute stages. The assignment schemas described in Chapter 3 will be referred as the Assignment Life Cycle (ALC) when implemented in the PL system. In general, the ALC will refer to the major tasks involved that often include creating a problem, creating a solution for that problem, and grading it.

While there are many open source or proprietary course management systems that support peer-evaluation, peer-feedback and self-evaluation practices, unfortunately there is not a simple solution available for instructors that readily combines all these practices while supporting complex assignments and examination schemas. The PL system has been fully developed from the ground up to ensure that instructors have the tools to tailor their assignments and examinations to fit their learning objectives while accommodating multiple types of schemas. The PL system is not a plugin or software module that integrates with an existing Learning Management System (LMS) but instead is a self-contained website that works as a standalone system. The choice to implement the PL system as a standalone website was to further increase its flexibility as it is not tied to a particular LMS and thus expanding the prospective pool of instructors that could participate in the study beyond NJIT. In fact, the studies that the PL system supported were conducted at two universities as described in Chapter 6 and Chapter 7.

As described in Chapter 1 regarding the main contributions of this study, while the website is an important aspect of the dissertation work in which I contributed by working on its design and user testing, the deliverables of the dissertation work do not focus on the website developed but instead focus on the evaluation of the PL approach applied to assignments and future design recommendations to improve the current PL system prototype.

4.1.2 PL System Design and Development

The PL system has been iteratively developed throughout several years by teams of students. As part of my contribution to the PL design and development effort, I have worked on the feature design of the PL system based on an initial set of requirements needed to implement the PL approach. In addition, I have also worked on designing the initial set of core backend database tables needed to hold course and assignment information and which was later expanded. These designs were subsequently implemented by other students on the team. At the same time, I have worked extensively in conducting usability studies and user interviews to determine issues that students and instructors have had with the system. Finally, my role as the initial system designer incurred added responsibilities to include management of specific development teams as needed.

For the first prototype, I primarily worked on the design of the frontend and backend while also engaging in usability studies to ensure that we had a robust design of our main user screen. The initial design of the prototype included the development and testing of multiple screens for the major features in the PL system including the Dashboard and Assignment Task Page. In addition, I worked on the database design that would support this original prototype and that was later extended in future implementations. Screens designed were developed using paper prototypes and then implemented in the PL system prototype. Once this prototype was developed, it was further improved upon during the following semester and piloted in a single Philosophy course. Throughout the years I collaborated with Professor Bieber and the multiple development teams by filling multiple roles that included management and support of capstone teams by helping present during the capstone open recruitment sessions, assisting with the evaluation of their work and providing support when needed, and in an advisory role for design to further improve the screens later developed. In addition, I have also worked with development teams during the summers including exchange students from India, Summer Undergraduate Research students and Capstone students. While my initial role was primarily design oriented, as the team expanded my obligations took on an additional advisory role by providing recommendations during our weekly development meetings based on findings made during interviews done throughout development. Currently, I am in charge of managing the experimental process and helping professors and students with issues they may encounter, which will be then passed on as a final set of recommendations for future development.

The initial version of PL system was primarily done on Drupal and coded using PHP. In this initial design in which I worked as the main designer, my main contributions were towards the design of user screens needed for the students to accomplish their tasks and also test these screens using the think-out loud protocol method. In addition, my contribution for this version was the initial set of database tables required to store information for the assignments.

The initial version of the PL system was developed as a modular add-on for the Content Management System (CMS) Drupal version 6. The idea of building the PL system as a Drupal module was based on the fact that, at that time, Drupal was a leading open-source CMS that allowed extending its functionality through the installation of modules. Therefore, this would allow schools interested in running the PL studies locally to simply download Drupal and then install the module we had created. While the initial prototype was successful and a few try-outs were conducted with it, the framework proved to be difficult to work with as it did not allow for the flexibility that was required to fully implement the PL approach. In addition, as new versions of Drupal were made available, several of the underlying modules in which the PL module was based on began to lose development support. Therefore, the stability of the system began to suffer and thus proved to not be as effective as initially conceived.

Due to the issues with Drupal, it was decided to instead use JavaScript to implement the PL system without using a CMS. Nevertheless, the initial front (user screens) and backend (database tables) that I worked on served as the base for the current PL system. The current PL system utilizes a combination of Node.Js, React, and SQL for the back and front-end. To ensure that the initial system design was implemented successfully, the development of the current PL website was managed and directed by me and Professor Bieber throughout several developmental cycles. As the designer of the initial core set of features for the PL system, I worked with several groups of developers to ensure they implemented the back-end and front-end to be able to meet the expectations needed to support the PL approach.

The project used GitHub as its software development platform. GitHub allowed the student teams who participated throughout the years to share a common repository from which every major update branched off. As a central repository, the GitHub master repository served as the source code that had updates pushed only after they had passed internal testing for consistency and reliability. This process ensured that the any future development of major updates was built from a working and tested code repository that reduced the likelihood of running into unexpected issues. In addition, GitHub allowed teams the chance of writing additional documentation to be used by future PL developers so that knowledge could be passed on across multiple teams. GitHub was also used to track issues in the PL system including errors found in different branches and issues raised during our pilot studies by the developers and users. For testing, this was done during each incremental iteration of the PL system to ensure that the stakeholders (instructors, students) requirements were met. Furthermore, I worked with the team to review with the development team weekly progress and conformity with requirements. Finally, we had a protocol that ensure that code had to run successfully and be approved before it was added to the main development branch.

Throughout development, my role has changed depending on the development stage and currently I am working on future recommendations for the PL system based on students' and instructors' interviews.

4.2 Similar Systems

Since PL required a lot of flexibility so that the assignments could be tailored to the instructors' needs, there was not a system that could meet this requirement. However, it was very important for me to ensure that we reviewed similar peer feedback and peer assessment systems so that we could not only draw inspiration from them but also evaluate ways that I could streamline the design of the system. I will classify similar systems into two groups: 1) learning management systems and 2) specialized peer assessment systems. In terms of learning management systems, there are several alternatives available. Open source alternatives include the widely used Moodle and other alternatives like Camilo, Open edX, Totara Learn, and Canvas. A study by Konstantinidis, Papadopoulos, Tsiatsos, and Demetriadis evaluated several Learning Management Systems (LMS) across two benchmarks, the first based on the wide assortment of tools and services offered, and the second based on adaptability, cost, expandability and interoperability. The following results present an aggregate score for each LMS based on the sum of both benchmarks (higher is better, total is 100) : ATutor 1.5.4 scored 70, Backboard Vista 4.1 Enterprise scored 55, Claroline 1.8.1 scored 55, Dokeos 1.8 scored 67, eCollege scored 52, FLE 3 1.4.2. scored 34, SAKAI 2.3 scored 72, ILIAS 3.7.7 scored 61, and Moodle 1.8 scored 73 [75]. In addition, from further evaluation of the capabilities of Moodle, it was shown that Moodle tools did not necessarily promote communication between students and their peers or instructors, as the main methods by students to contact their instructors were face-to-face meetings, phone calls, and emails. In addition, students were shown to be less likely to contact others using indirect methods such as a forum, hence, making Moodle contributions towards peer communication not as significant [75].

Another study by Lin that evaluated Moodle 2.0 discussed additional modules developed to improve peer collaboration including the *Wiki* module that allowed instructors to easily provide a ‘knowledge building’ environment. In addition, the *Workshop* module that was a redesigned feature from a previous version allowed for multiple types of assessment forms allowing the learner, peers, and instructors to evaluate the quality of work [76]. However, while the functionality for peer evaluation and assessment has greatly improved, they are still limited in how they deal with complex assignments, and thus our current PL was developed to meet this need.

Other systems explored were specialized systems especially developed from the 'ground up' for peer assessment and peer feedback instructional practices. A meta study by Babik et al. [77] formulated a research framework for a taxonomy of educational peer assessment systems. They evaluated and identified several primary objectives such as eliciting qualitative and quantitative peer evaluations. The systems investigated included Calibrated Peer Review, CritViz, CrowdGrader, Expertiza, Mobious SLIP, Peerceptiv, and peerScholar. The framework presented discussed the primary objective of these systems in five different categories: a) eliciting evaluation, b) assessing achievement and generating learning analytics, c) structuring automatic peer assessment workflow, d) reducing or controlling for evaluation biases, and e) changing social atmosphere of the learning community. The review by Babik et al. [77] determined several system-dependent features that peer evaluation focused on in order to elicit quantitative and qualitative peer evaluations. For quantitative peer evaluations, features implemented in these systems included rubrics and scales. For rubrics, there were two specific categories considered for their design options and that informed our early design which we then used for pilot studies. The categories considered were holistic and specific rubrics. For holistic rubrics, a submission was considered in its entirety and evaluated as a whole by being represented by a singular value. For specific rubrics, the submissions were broken down into different distinct criteria. The other design consideration was the use of scales by the utilization of ratings or ranking. When using ratings, the individual compares different items against a common absolute scale that can be numeric or categorical. On the other hand, ranking refers to the comparison of items against other items so it is relative in nature. For qualitative peer evaluation, there were several features implemented including critique artifact media types and contextualization of critiques. For critique artifact media types, there were several design options explored such as plain text, rich text, inline file annotation, and multimedia attachment. Plain-text referred to comments written in a simple text box and then given to a user. For rich text, several systems gave the ability to users to use bullet points, different text sizes, and the ability to link external sources. In-line annotation provided students to further enhance their critique by allowing them to select specific portions of a document and annotate them in place. Finally, due to the limitations of text-based critique in offering expressiveness, an alternative suggested was allowing users the ability to attach media files containing critique artifacts including images, audio, and video recordings. Contextualization of the critiques is another important element of qualitative evaluations. There are two types of contextualization explored, detached and contextualized. Detached refers to non-contextualized critique commonly available in most systems as a single comment per submissions. Contextualized critique refers to the ability of users to provide multiple comments in various fragments of the submission [77]. Overall, the meta-analysis and exploration of several other systems informed and guided the initial design and implementation of the PL system initial prototype features including dashboard, task pages, grading rubric categories and others.

Another system reviewed was PeerWise developed by Denny, Hamer, Luxton-Reilly, and Purchase that was developed and used in the University of Auckland, New Zealand and Glasgow, United Kingdom. Unlike other peer evaluation systems, PeerWise takes a different approach by allowing multiple-choice question banks to be developed from student input. According to the researchers, PeerWise provides a number of intrinsic rewards structures that encourage students to contribute high-quality questions without the need of an instructor intervening. This allows different opportunities from learning ranging from reflective study to drill and practice exercises. In addition, PeerWise encourages students to provide and receive critical feedback and also evaluate others' work [78].

Therefore, PeerWise offers an innovative approach that enhances standard teaching and learning practice that prompts students to participate in the creation and assessment of multiple choice questions. In doing so, the system encourages the development of higher order cognitive skills while not creating additional work for the instructional staff [79]. PeerWise was conceived as a student-created web-based repository of multiple-choice questions with the questions and explanations themselves being made by the students. It should be noted that the act of creating, assessing, rating, and providing feedback about the multiple choice questions is confidential [79]. The first PeerWise study was done in a large class of 500 students during a 12-week semester. Students were required to develop at least two questions and then answer and rate another 10 questions for 2% of their final grade. The deadline for the contribution was about 5 weeks after the system was presented to the students. The system usage was analyzed from the day of introduction until the day of the final exam. There was a two-week period from the coursework deadline around June 1st and the final exam around June 15th – the researchers called this the study period. Results from the study indicate a heavy uptick in contributions days prior to the coursework deadline after which few questions were added. In addition, during the study period, the system was used heavily for practice which meant that the students saw real value in the repository of questions developed by them. In addition, researchers noticed that during the study period the questions were being answered at a faster rate than prior to assessment deadline [79]. Further studies on PeerWise also demonstrated that students ended up providing additional questions over what they needed to and even used the system voluntarily to prepare and study right up to, and in some cases after, the final exam [80]. Students reported that PeerWise was enjoyable to use and would like to see it used in other courses. Researchers' quantitative results suggested that it was the question and feedback contributions by students that improved their learning rather than 'drill and practice' exercises they participated before their final examinations [81].

Regarding the quality of the questions, further research on PeerWise demonstrated that students were capable of writing high quality questions. These questions had good written questions stems, good distracters, and explanations about possible misconceptions. Whereas the quality of the questions did indeed end up varying to certain degree, students were able to pass accurate judgements about the questions' quality and rate them accordingly. These ratings ended up correlating with that of the instructors. In addition, further analysis of a sample of the questions demonstrated that they were clear and unambiguous, free or with few grammatical errors, and had a good number of distracters and explanations. Also, the structure of the questions written by students was similar to the ones used by instructors teaching the course [82].

4.3 PL System Features

4.3.1 Instructor Features

Assignment Editor: The most important tool available for instructors is the ability to fully customize the workflow (i.e., the schema) of assessments and examinations. In the PL system, each assignment (or examination) is made up of tasks that prompts a student to provide content like a question (make up a question) or a solution (provide a solution), assess other bodies of information (grade others work), or revise content generated by themselves or others (revise and resubmit). The current flexibility of the assignment editor allows each task to have sub tasks as needed thus allowing for the creation of complex coursework workflows. (See Figure 4.1.)

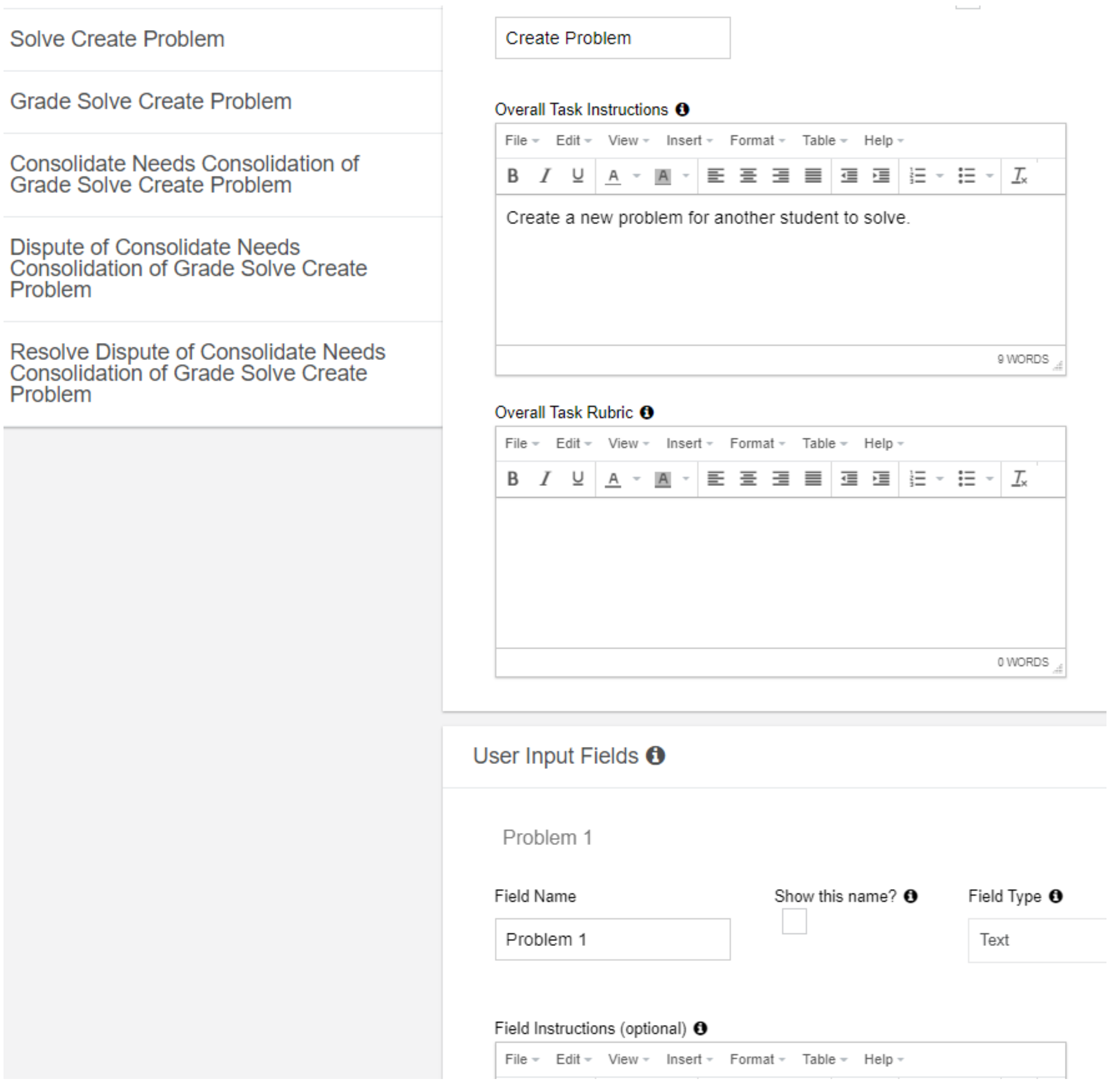


Figure 4.1 PL assignment editor.

The following are two workflow examples: A traditional assignment workflow would ask a student to create a question, ask someone else to solve that question, and then have two other students grade that solution. If needed, the person who solved the question can then accept his or her grade or further dispute it with an instructor. A more complex workflow would have the same start where a student would make up a question. However, the quality of this question would be graded by another student. In addition, that student would be asked to revise the question and send it back to the initial student if the question quality is not up to par. The quality of a question would be evaluated based on a set of criteria determined by the instructor. Once this quality threshold is acceptable, this would then go to a third student to be solved. The solution would then be graded by two other students and then the final grade would be sent back to the person that provided the solution. In the meantime, the quality of the assessment could be further graded by another student to ensure that students can learn from others as they provide an assessment on a solution. The overall grade can be a combination of how well a student made up a question, the accuracy of the solution, the quality of the student's grading provided by someone else and the timeliness of their task completion. Therefore, the current PL system allows instructors to create complex assignments tailored to their course learning objectives.

Assignment Management Tool (AMT): Another important tool that allows instructors to manage the classroom assignments and examination is the AMT. The AMT stores all the workflows containing the course ALC so that the instructor can use assignment workflows from the current course being taught, or from other courses that the instructor participates in. The reuse of these workflows allows instructors to standardize assignments across multiple sections while allowing to reduce the overall amount of work they need to commit into the system to have all the assignments and examinations be uploaded for their section(s). At the same time, the AMT allows the instructors to setup due dates for each task within the assignment so that they can modify the deadlines for their students as needed and in response to the ever-changing dynamics of the classroom. (See Figure 4.2.)

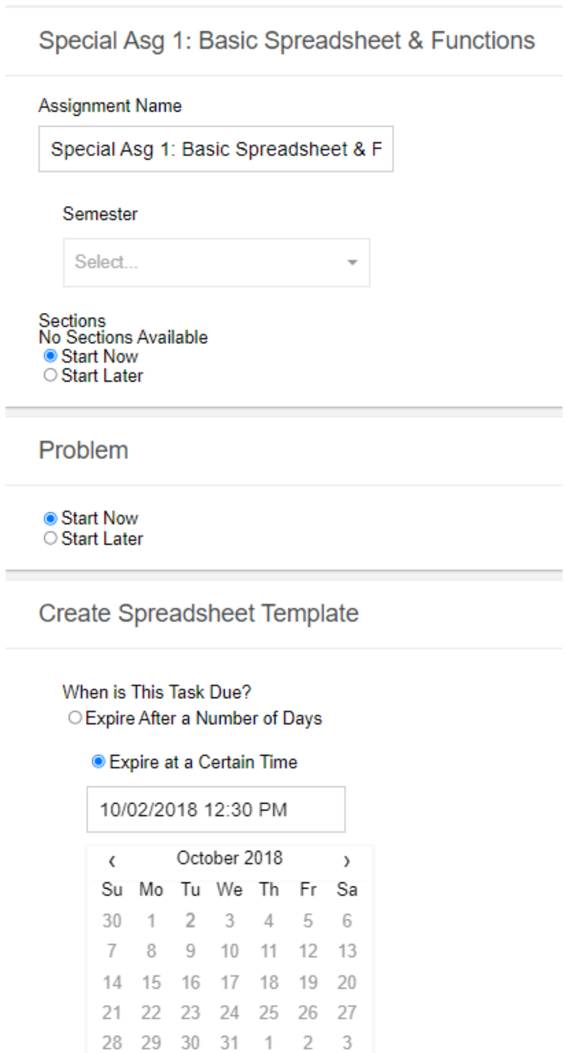


Figure 4.2 PL assignment management tool.

Assignment Status Page (ASP): The status page is a dedicated master table that lists all the instances within the assigned assignment or examination workflow. For example, in a class of ten students, depending on the settings that the assignment was based on, at a minimum there will be at least ten different instances of that assignment. In this case, for example, every single student in this ten-person class could be asked to come up with their own question and thus for this assignment there will be ten questions to keep track of. Once the questions are created, then the questions are solved and graded by students from the same class. Whereas keeping track of ten questions could be a difficult challenge, the effort required to track not only the ‘Question creation’ task but also other tasks increases the size and complexity of the assignment increases as well. Therefore, we have developed a visual, color-coded, master table that is divided into rows and columns. Each row tracks an instance of the assignment and each column tracks the task progress stage of that instance. For example, going back to our previous example with ten students, the ASP table would have each row correspond to a specific instance of the assignment (in this case a question). As students complete their tasks assigned (problem creation, solving, grading), the table would then display their progress using a detailed color schema including green for completed, red for late tasks, yellow for cancelled tasks, and blue for tasks in progress. (See Figure 4.3.)

In addition, the ASP has two modes which are Public and Private. The private mode displays information to the instructor related to the task at hand including the name and email of the individual assigned to the task and a direct URL link to the task so that the instructor can review it. The public mode hides identifiable information such as the individuals’ names in order to maintain the anonymity of the assignment. This feature is useful for instructors who want to show their classroom the current stage of all the assignments so that the class has a better understanding of the current stage of the assignment and make changes as needed.

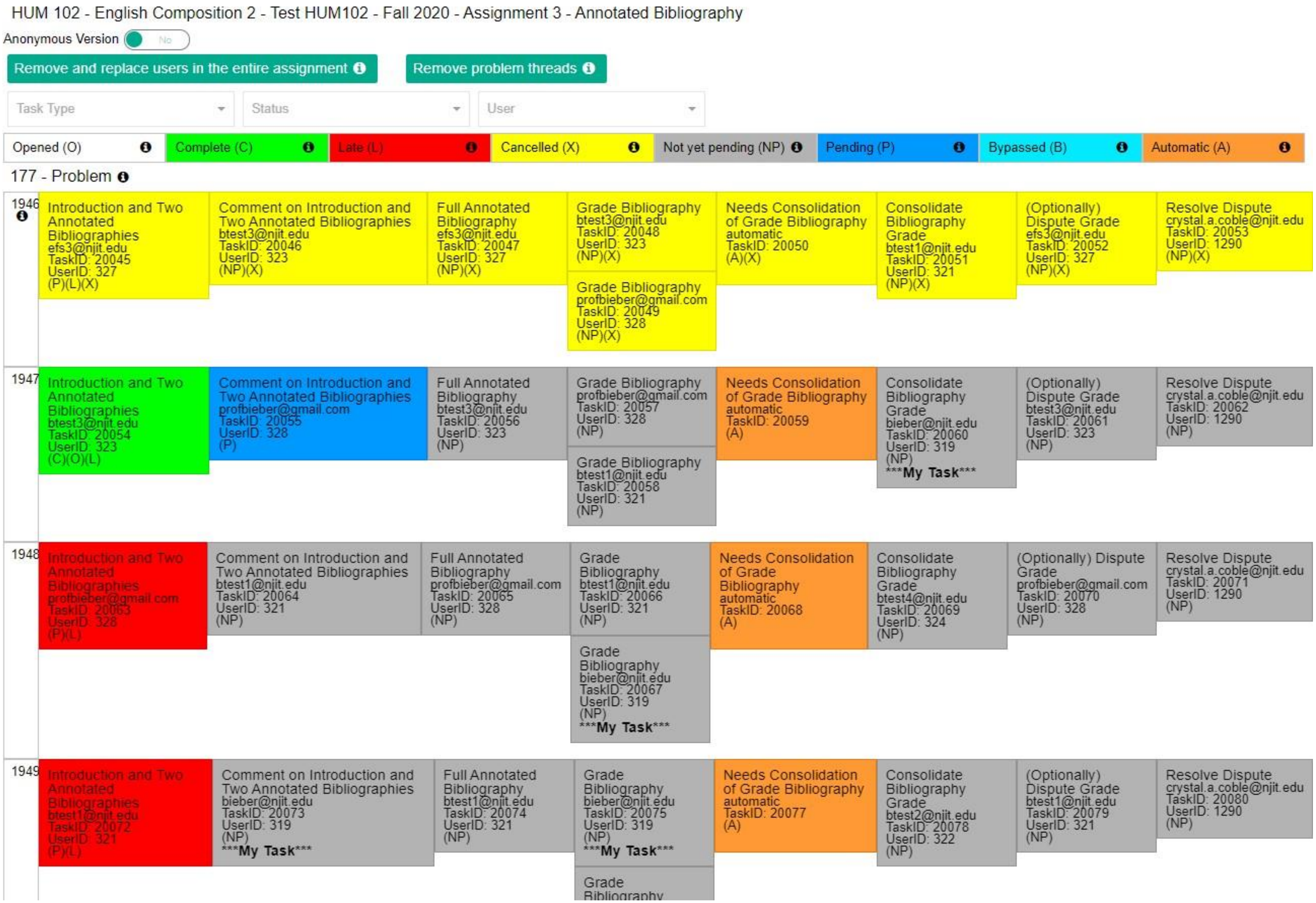


Figure 4.3 PL assignment status page.

4.3.2 Student Features

PL Dashboard: The dashboard is a feature that is available to both students and instructors. However, its design is driven by the needs of students primarily. The dashboard's main useis to guide and facilitate students' access to their assigned tasks. The dashboard minimalistic design displays all the currently assigned tasks to the individual (student or instructor) along with a direct URL to the task at hand. This allows individuals to quickly gain access to work on what they have been assigned. In addition, the dashboard also provides task deadlines so that students can prioritize their work as needed. The dashboardinterface for instructors and students mostly remains the same as it is primarily based around the tasks assigned. See Figure 4.4.

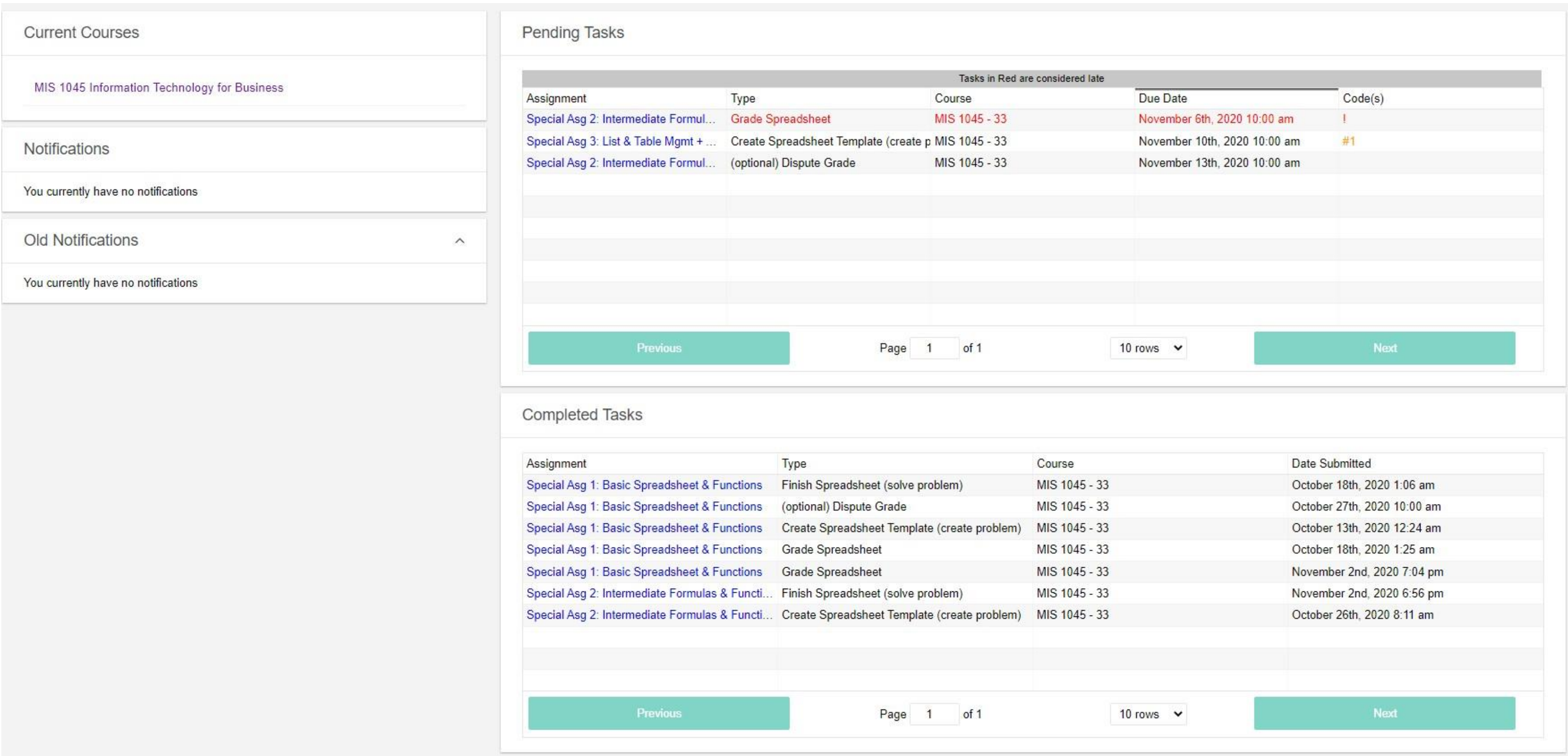


Figure 4.4 PL dashboard.

Student Assignment Status Page (SASP): The SASP is a feature in our system thatprovides students with a targeted minimalistic status table that displays only the tasks assigned to the student within a specific course assignment. The SASP allows the studentsto check only the assignment instances in which they are part of and therefore, rather thandisplaying a master table with all the tasks assigned to everyone, it will only display relevant information to the student. See Figure 4.5.

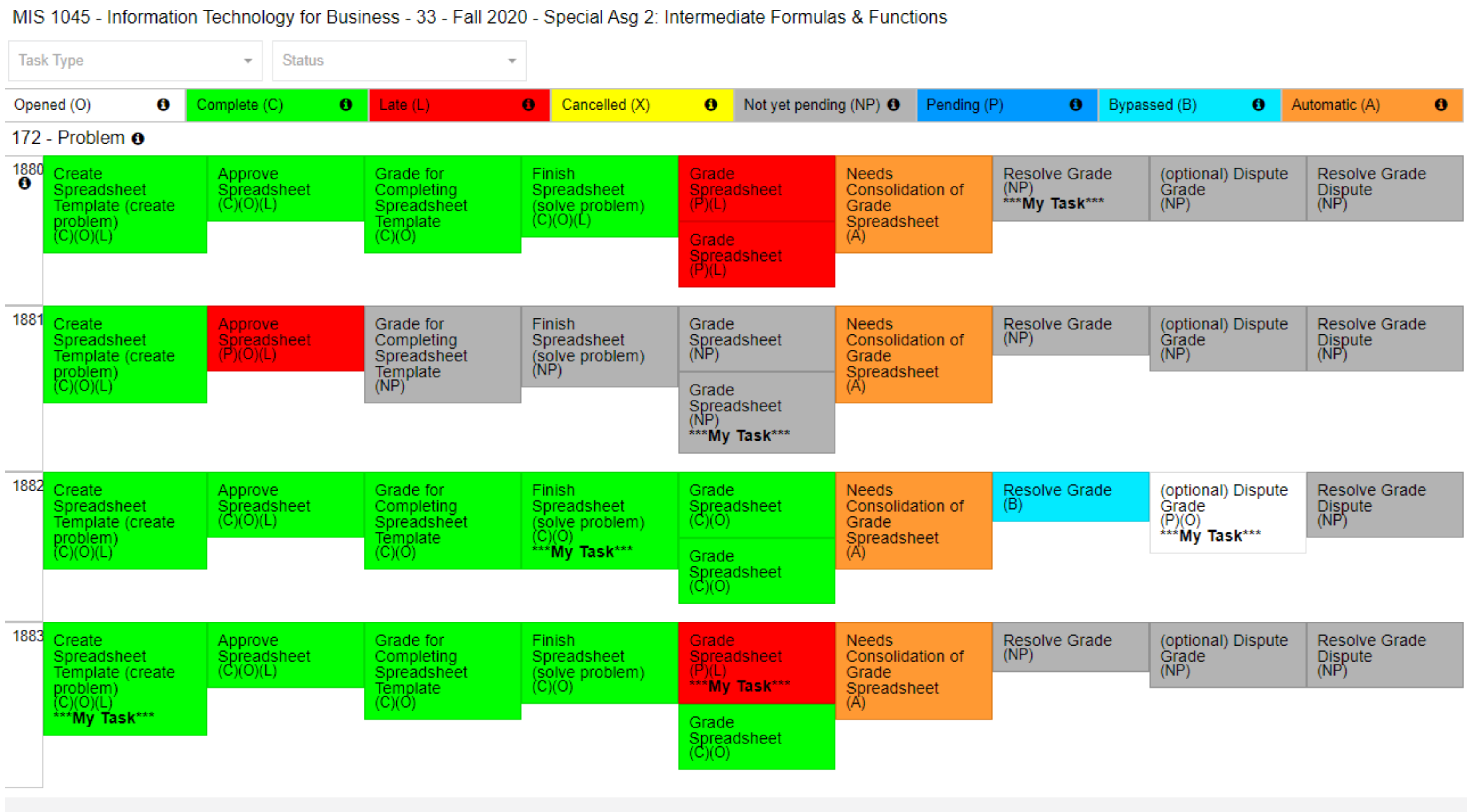


Figure 4.5 PL student assignment status page.

Task Submission Page (TSP): The TSP Is a customizable and dynamic task page that adapts to the type of task assigned. Students are prompted with a task page only when they have to provide some kind of input and thus activities that are done automatically like grade reconciliation or tasks that have been skipped only provide student with a notification. The TSP can be customized to accommodate simple and complex user input. For simple student input requests, the TSP will have few input dialogs boxes for the user to complete. However, when complex user input is requested, the TSP will include additional drop down windows used for grading schemas, file upload add-ons for user-generated files in addition to special text-fields that allow for the input of complex math signs and formulas. (See Figure 4.6.)

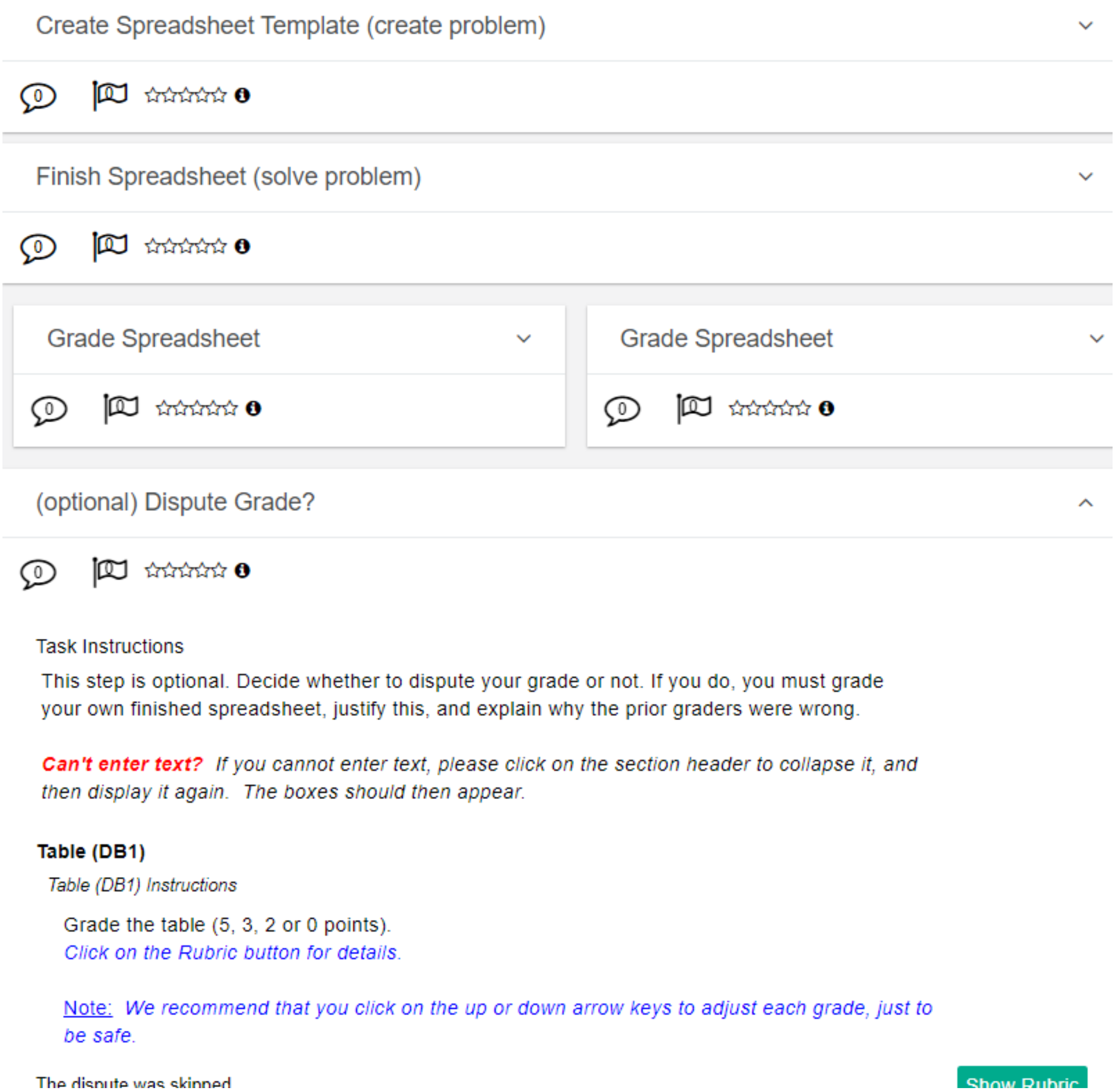
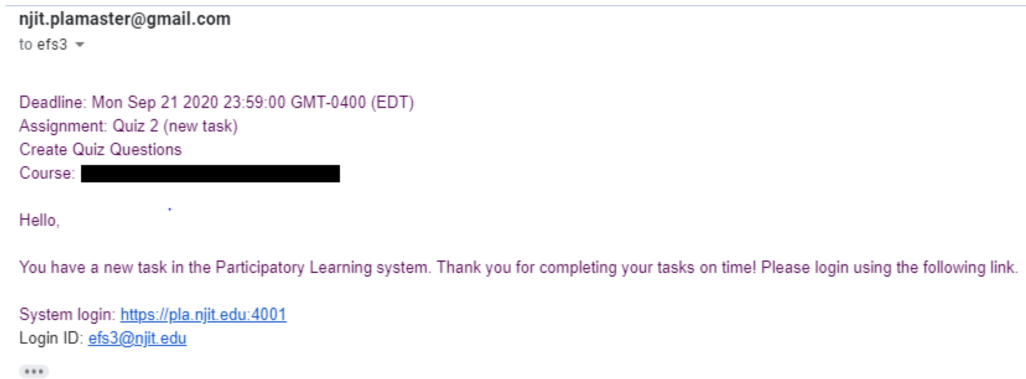


Figure 4.6 PL task status page.

Email Notification System: The notification system is closely tied with the PL system and works seamlessly in coordination with the task scheduler. When the task scheduler assigns a new task to the student, the email notification system triggers an email response that notifies the student of a new task so that they visit the PL system. By default, a student receives an email every time they have been assigned a task. (See Figure 4.7.)


njit.plamaster@gmail.com
to efs3

Deadline: Mon Sep 21 2020 23:59:00 GMT-0400 (EDT)
Assignment: Quiz 2 (new task)
Create Quiz Questions
Course: [redacted]

Hello,

You have a new task in the Participatory Learning system. Thank you for completing your tasks on time! Please login using the following link.

System login: https://pla.njit.edu:4001
Login ID: efs3@njit.edu

Figure 4.7 PL email notification.

4.4 Summary

This chapter begins by describing the PL system history including a description of my contribution to its design and development. This chapter also provides an overview of similar systems that helped determine important features for the PL system. As explained in this chapter, while there were multiple LMS that allowed for peer feedback and peer assessment activities, they were not able to support the complexity assignments of the PL approach. Therefore, the core features developed as of part of the PL system used for the preliminary and main dissertation study as described in Subsection 4.3 would help instructors manage the PL approach and also help students work on their tasks.

CHAPTER 5

PARTICIPATORY LEARNING MODEL

The evaluation of the model by Wu, Hiltz, and Bieber when applied to assignments and its further extension to account for critical thinking and system use is an important aspect of this research as outlined in my Main Research Question #2: Do the hypotheses in the model used by Wu, Hiltz, and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?

Therefore, this chapter will introduce the Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, and the Wu, Hiltz, and Bieber model, and then describe the proposed PL model which includes additional constructs to account for System Use and Critical Thinking.

5.1 Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology

My proposed research model is an extension of the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (see Figure 5.1) tailored to PL assignments developed by Wu, Hiltz, and Bieber [2]. Building upon Wu et al.'s original model, many constructs remain the same or have been altered to include additional measures. In addition, I have also added additional constructs to include critical thinking and system use. The original constructs included are Facilitating Conditions, Effort Expectancy, Performance Outcome, Perceived Learning, Perceived Enjoyment, and Recommendation for Use.

The Technology Acceptance Model (TAM) has been widely used in the field of Information Systems to predict acceptance and use of technology. According to the TAM, actual system use is influenced by users' behavioral intention to use. In turn, behavioral intention to use is influenced by the attitude towards using a technology which refers to the overall impression about a technology that users have formed. In addition, there are two factors that affect the user attitude towards usin*g* a technology. The first factor refers to perceived useful which was defined by Davis as the user's belief that a particular system would enhance their job performance. The second factor is perceived ease of use which was defined by Davis as the degree a user believes the system would be free from effort [13]. According to Bagozzi, Davis, and Warshaw:

> "Because new technologies such as personal computers are complex and an element of uncertainty exists in the minds of decision makers with respect to the successful adoption of them, people form attitudes and intentions toward trying to learn to use the new technology prior to initiating efforts directed at using. Attitudes towards usage and intentions to use may be ill-formed or lacking in conviction or else may occur only after preliminary strivings to learn to use the technology evolve. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions." [83].

The TAM has continuously been worked on throughout the years and since then it has been further expanded by Venkatesh through the Unified Theory of Acceptance and Use of Technology. The UTAUT is a technology acceptance model that seeks to predict user acceptance and usage behavior based on four direct determinants: performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC). According to Venkatesh, Morris and Davis [12]:

1. Performance expectancy is defined as the degree to which an individual believes that using the system will help him or her attain gains in job performance. Performance expectancy seems to be the strongest prediction of intention and remains significant at all points of measurement measurements in both voluntary and mandatory settings.

2. Effort expectancy is defined as the degree of ease associated with the use of the system.

3. Social Influence is defined as the degree to which an individual perceives that others believe he or she should use the new system. Thus, individual's behavior is influenced by the way in which they believe others will view them as a result of having used the technology.

4. Facilitating conditions are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.

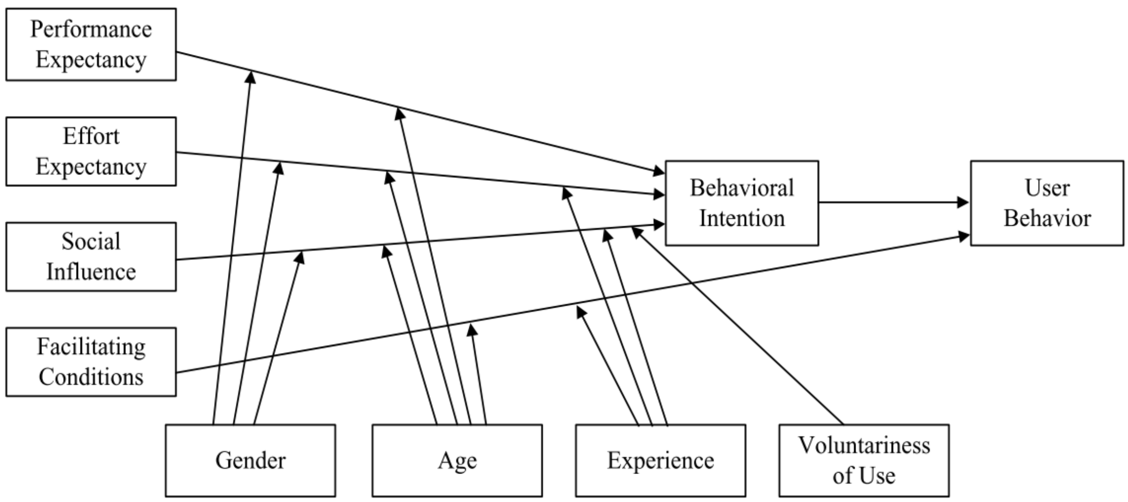


Figure 5.1 UTAUT model by Venkatesh, Morris and Davis [12].

Wu, Hiltz, and Bieber worked on adapting the TAM and UTAUT model to measure student acceptance of educational technology (see Figure 5.2). In their model, Facilitating Conditions had a positive and significant relationship with Perceived Learning and Perceived Enjoyment. Effort Expectancy had a negative and significant relationship with Perceived enjoyment. In addition, Perceived Enjoyment had a positive and significant relationship with Perceived Learning and Recommendation for Use. Finally, Perceived Learning also had a positive and significant Relationship with recommendation for Use. These constructs have thus formed the core of the PL model which extends this model and is further explained in this chapter.

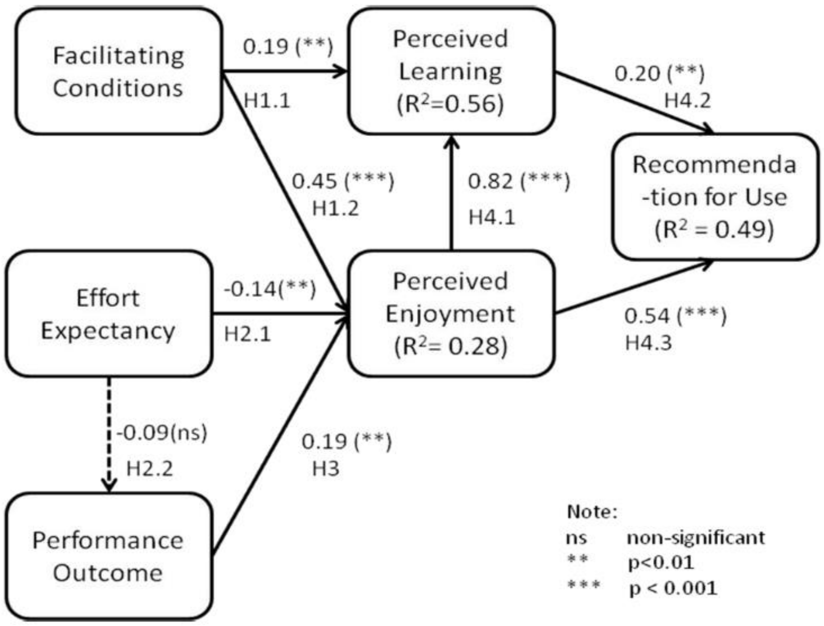


Figure 5.2 Wu, Hiltz and Bieber model [2]**.**

5.2 Participatory Learning (PL) Model

Part of my dissertation work focused on extending Wu, Hiltz and Bieber model to also account for measures of System Use and Critical thinking (see Figure 5.3). My PL model (which refers to the modified model by Wu, Hiltz, and Bieber) tailored to not only measure student acceptance for participatory assignments and exams but also aims to predict how the PL approach affects students' perceived and actual learning in addition to adding constructs for system use and critical thinking. An important similarity between my dissertation and the original study designed by Wu, Hiltz and Bieber is that participation in the study was mandatory for the treatment class as it was included into the class workload and thus it would not be useful to predict intention of use for the PL approach. Instead, my expanded model focuses on explaining why students would prefer to adopt the PL approach not only for their exams but also for the course assignments. Two important variables in the PL model are Recommendation for Use and Actual Use that are used to measure student process adoption.

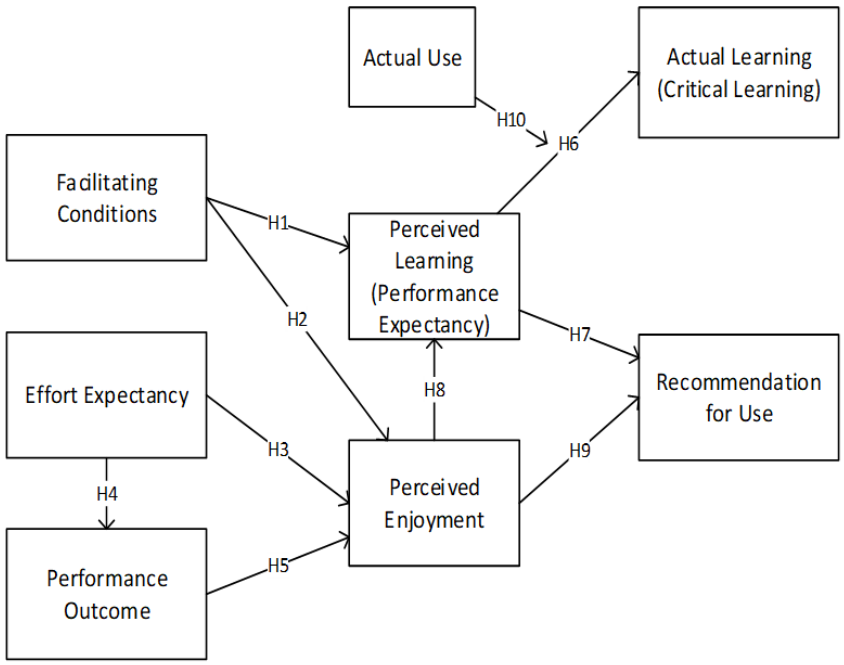


Figure 5.3 PL model. The H#s in each line connecting the constructs refer to the hypotheses used to evaluate the model.

5.3 PL Model Variables

The current study extends the Wu, Hiltz, and Bieber [2] "Acceptance of Educational Technology" research. As such, the majority of our questions extend from the original study. Therefore, I reused the questions from the original study while modifying them accordingly to fit the current study that focuses on assignments rather than examinations. In addition, I used questions from two other studies for perceived learning and system usability. I further measured perceived learning using the Cognitive, Affective and

Psychomotor (CAP) learning scale developed by Rovai, Wighting, and Baker [84]. In addition, I utilized the System Usability Scale (SUS) developed by Brooke in 1996 [85].

The Cognitive, Affective, and Psychomotor (CAP) learning scale contains three sets of questions with three questions each that feed into three constructs for perceived learning respectively: 1) Cognitive, 2) Affective and 3) Psychomotor. However, due to the PL not directly influencing the learning of any Psychomotor skills, I have only used questions related to Cognitive and Affective. The CAP scale was developed as three separate scales and thus it was possible to eliminate questions without affecting its validity and reliability [85]. Regarding the SUS, I used all ten inventory questions provided in the original instrument. A study by Bangorm, Kortum, and Miller in which they presented ten years' worth of SUS data on different products concluded that the SUS was a robust and versatile tool that allowed for easy and quick collection of users' ratings on a product usability [86].

5.3.1 Independent Variables

Facilitating conditions (FC) is a variable adapted from the Wu, Hiltz, and Bieber study which represented the clarity of tasks, perceived quality, and fairness of the exam and grading procedures [2]. According to Venkatesh, Morris, and Davis, one of the root construct definitions of facilitating conditions describes them as "objective factors in the environments that observers agree make the act easy to do" [12]. As such, I consider the degree of instructor help and coordination to influence the students' perceptions of the facilitating conditions variable.

For the purpose of the current study, clarity of the tasks refers to how well the instructor explained the PL assignments, which refers to the guidelines provided for problem creation, problem solving, and grading. Perceived fairness in the assessment criteria refers to the perception of students related to how they got graded by their peers. Degree of instructor help relates to how much each instructor helped other students coordinate and navigate through the assignments including whether they provided help to their students through introduction of the PL system and/or allowed class time to work on the assignments. See Appendix A.1.

In terms of *Actual Use (AU),* given that the students do not have a choice whether or not to interact with the system, I have instead measured the number of assignments completed.

5.3.2 Intervening Variables

Effort Expectancy (EE) is an intervening variable in our model. Effort Expectancy is a variable adapted from the Wu, Hiltz, and Bieber study which is measured in this context by how easy or difficult the course is perceived to be [2]. The questions for effort expectancy are the same as in the original study and have not changed as they originally referred to the perceived degree of expected difficulty for the course. See Appendix A.2.

Performance Outcome (PO) is also a variable adapted from the Wu, Hiltz, and Bieber study, which refers to the grades earned in the participatory learning examinations in the original study [2]. This will be modified slightly due to the fact that instead of examinations, our current PL approach focuses on assignments. Therefore, our performance outcome measures will be based on the grades earned on all PL assignments during the semester.

Perceived Enjoyment (PE) is a variable adapted from the Wu, Hiltz, and Bieber study [2]. According to the original study, the intervening variable “enjoyment” substitutes for Perceived Ease of Use in TAM and in their research the construct combines aspects of enjoyment, flexibility, and motivation to succeed [2]. In the current study, I will evaluate this construct through measures of perceived flexibility, perceived pressure, perceived anonymity, perceived facilitation of process by the PL site, perceived degree of motivation, and perceived overall enjoyment.

Perceived flexibility will refer to the degree of flexibility that the approach offered to students and is similar to the flexibility aspect in the original construct. Perceived pressure refers to the degree of perceived burden that the approach placed on students and that is one of the aspects of enjoyment from the original construct. Perceived anonymity refers to the degree of lack of recognizability that was also an aspect of enjoyment from the original construct. Perceived degree of motivation refers to the innate willingness to engage in the participatory learning process and that was also part of the original construct as motivation to succeed. Perceived overall enjoyment refers to the degree of satisfaction that the students derived from participating in the process.

While in the past study by Wu, Hiltz, and Bieber [2] students were somewhat familiar with the system being used (their learning management system), for the PL approach study the system used was newly built and thus was unfamiliar to the students. In order to measure perceived ease of use, I have used the System Usability Scale [85]. In addition, I have also directly asked students a question related to the degree of perceived facilitation of the process by the PL site which is used as a secondary measure related to the system usability. See Appendix A.3.

*Perceived Learning (PL*e) is an adapted variable from the original model developed by Wu, Hiltz, and Bieber [2] where PLe was the equivalent to Performance Expectancy within the educational context. In addition, in the original study Perceived Usefulness was seen as “the equivalent to the perception by students of their learning, since Perceived Usefulness is regarded as the belief that [Information Technology] use will improve one‘s performance” [2]. I also apply the same description to PLe in the current study and reuse the same questions from the original study. Perceived Overall Learning refers to the overall perception students have of learning regardless of the use of the PL system. In addition, I also ask questions about the students’ perceived learning as part of the PL approach. Finally, I also collect measures of perceived learning though the use of the CAP learning scale by Rovai, Wighting, and Baker [84]. See Appendix A.4.

5.3.3 Dependent Variables

Recommendation for Use (RU) is also a variable adapted from the Wu, Hiltz, and Bieber study which substitutes for Behavioral Intention as the measure of acceptance, since students in a course do not have any choice over whether or not to use the PL approach. [2]. In our study, students also do not have the option to choose whether to use the system or not as the assignments are uploaded into the PL system. Therefore, in the current study Recommendation for Use also refers to students’ attitudes towards suggesting the use of PL for the course they participated in. See Appendix A.5.

Actual Learning (Critical Learning) is the main dependent variable for the model as I aim to understand whether students did in fact improve their ability to think critically from participating in the PL approach. Given that assignments and exam grades do not always accurately represent learning, I have created and administered at the end of semester question that tests for ‘critical thinking.’ In this question, students were not only asked to answer the question provided, but also to clearly outline their thought process when answering the question. Students are asked to not only provide a final solution, but also to understand the problem presented, derive choices for possible answers, analyze each choice, and then present a coherent argument to explain how they arrived at a solution presented. I have aimed to collect measures relevant to the six core critical thinking skills developed by Facione. These skills are outlined in Appendix A.6 [87].

To guide and evaluate the critical thinking process, in collaboration with the instructor I have created questions for each course which ask the students to solve the following the IDEALS critical thinking process framework outlined by Facione [87], [88]. IDEALS stands for:

1. Identify the Problem: What is the real question we are facing?
2. Define the Context: What are the facts that frame this problem?
3. Enumerate the Choices: What are plausible options?
4. Analyze Options: What is the best course of action?
5. List Reasons Explicitly: Why is this the best course of action?
6. Self-Correct: Look at it again … What did we miss?

Using the critical thinking framework by Facione allowed us to create a question that could be used in both treatment and control sections for comparison for each course. While I could have asked students to come up with a problem or grade each other as part of their evaluation, only students in the treatment sections would have practice doing this and thus would not have been fair to the control section. Using Facione's critical thinking framework allowed us to create a more neutral question that I could then use for comparison purposes with the help of the instructors in charge of the course.

5.4 PL Model Data Collection

5.4.1 Survey

For the pilot study, I have utilized a single survey broken down into parts. The first part included measures related to the PL system including questions about usability, perceived enjoyment, and learning from using the system. The second part of the survey contained questions related to overall measures of perceived learning. The third part of the survey collected information about the student and general measures of effort expectancy and enjoyment in the course. In the first part of the survey, I collected additional measures for system usability by including questions from the System Usability Scale (SUS) which has been widely used to evaluate information systems [86]. As our research model extends the Participatory Examination Research Model by Wu, Hiltz, and Bieber [2], the questions are similar since their questions were also reused in the survey but it also included additional questions to account for new constructs. With respect to the validity of the new questions added, the new questions related to Perceived Learning came from Rovai's Perceived Learning scale which is a standardized instrument that has been tested for validity and reliability [84]. Regarding the CAP instrument, I only included inventory items relevant to the cognitive and affective learning subcategories. In addition, for the questions related to usability, I used the System Usability Scale (SUS) developed by Brooke in 1996 that is also an standardized instrument used extensively in research [85]. Also for the control group, the survey was modified by removing any mention of the PL approach or the system itself. It should be noted that, for the main dissertation study, the survey was given twice to the students in addition to a small survey at the beginning of the study to collect general demographic information. Additional information about the methodology of the pilot and main dissertation study will be further explained in Chapters 6 and 7, respectively.

5.4.2 Critical Thinking Question

I have worked with the instructors to create a question that tests the students' critical thinking skills through the application of the IDEALS framework. [87], [88]. The question was given at the end of the semester as 1) a question in the final exam or 2) a quiz or assignment in CANVAS or the LMS of choice of the instructor.

5.4.3 Interviews

I have also collected qualitative data through semi-structured interviews with students in the treatment groups. I have focused on understanding the students' perceptions of learning and satisfaction after using the PL system. Issues explored include: 1) perceived differences in learning between regular PL and traditional assignments, 2) perceived differences in learning between micro-tasks and traditional assignments, and 3) perceived satisfaction from being part of the PL approach. Data collected has also helped provide more context to the findings derived from quantitative analysis. The interview protocol can be seen in Section A.7.

5.4.4 PL Assignment Grades

I have collected grades earned by the students from the PL assignments they have completed in both of the treatment groups. Grades collected include the individual grade given by each grader (if more than one grader), the consolidated grade and any other modification to the final grade for the assignment if the students decide to dispute it. For tasks with multiple grading criteria, I collected the grade for each individual criterion in addition to their aggregate grade.

5.4.5 Student System Use

Measures of System Use from students were collected primarily through the recording of the number of assignments completed throughout the semester and total number of assignments. While ideally all students will complete all assignments, this does not occur normally due to a) the unlikelihood of a class to have 100% assignment completion and b) differences in the number of assignments students are given by instructors which depend on the learning objectives and activities set by them for the course.

5.4.6 Course Grades

In addition to the grades collected from the critical thinking questions, I have also collected the grades from regular assignments from the control group and also the examinations given in class for all groups which include midterm (whenever available) and final exams, and end of semester course grade.

5.5 PL Model Hypotheses

The following PL Model hypotheses do not test the research questions outlined in Chapter 1 but rather test relationships in the PL model. However, it should be noted that in Research Question 2 does discuss how the PL model can be extended and as such these hypotheses extend on the model developed by Wu, Hiltz, and Bieber [2].

5.5.1 Facilitating Conditions (H1, H2)

"Facilitating conditions" is an independent variable that is borrowed from the original model developed by Wu, Hiltz, and Bieber [2]. Facilitating conditions include clarity of the tasks, perceived fairness criteria for grading, and degree of instruction help. Therefore, it will be very important for the process to be clear and fair to students for them to be able to buy into using the system for their assignments. While in the Wu, Hiltz, and Bieber study this was tested on examinations, for our proposed study we will use the PL approach on assignments throughout the semester, thus the appropriate facilitating conditions are important so that students actively participate in the Participatory Learning process.

Perceived fairness of the assessment is important as mentioned by Wu, Hiltz, and Bieber [2]given that is an integral part of the learning process as students not only become actively engaged with creating their own problems and solutions, but also act as graders for others. Although research has shown that peer-assessment has high-agreement to instructor grades [38], it should be noted that there is also the possibility of grade inflation as a consequence of use of student evaluation [89] and as such we want to closely monitor the effect of perceived grading fairness.

H1: Students who perceive improved facilitating conditions will perceive increased learning

In addition, we also argue that if a student is negative about the facilitating conditions (i.e., fairness of grading), they will tend to be negative about the entire PL approach. In contrast, students who are positive about the facilitating conditions will tend to buy into the PL approach. Therefore, despite the fact that the grading could be explained clearly to the student and made 'fair' in the eyes of the instructor, it will ultimately be the students' perception of fairness that will lead them to enjoy the PL approach and buy into it. Therefore, we hypothesize that perceived enjoyment will be positively affected by improved facilitating conditions.

H2: Improved facilitating conditions lead to an increase in perceived enjoyment

5.5.2 Effort Expectancy (H3, H4)

Effort expectancy refers to the perceived difficulty of the course to students. Students who believe that the course is more 'difficult' than others in which earning higher grades is harder could potentially see their perceived enjoyment diminished as well.

H3: Students who perceive a higher degree of effort expectancy will derive less enjoyment from the PL approach

In addition, students who believe that the course is easier would expect higher grades. We believe that students who have low effort expectancy for the courses will be more likely to expect to receive higher grades. Whereas in the Wu, Hiltz, and Bieber study effort expectancy and performance outcome had a non-significant relationship, we will evaluate this relationship since students will be using the PL approach throughout the semester. When compared to the previous study, students only used PL for examinations and thus there could be a change in the significance of the relationship. As students' effort expectancy perceptions are more likely to be affected due to the continuous use of the PL system throughout the semester, we believe this would significantly affect the performance outcome of students.

H4: Students who perceive a higher degree of effort expectancy will have lower performance outcomes.

5.5.3 Performance Outcome (H5)

Following the model outlined by Wu, Hiltz, and Bieber [2], grades are seen not as an extension of learning, but as a way to affect students' perception of learning. Nevertheless, as high grades can be seen as an extrinsic reward for learning, they serve as a motivator for students and could end up affecting their perceived enjoyment. As a result, we argue that as performance outcomes increase, so does the student's perceived enjoyment. For our study, this will be particularly important to test given that while Wu, Hiltz, and Bieber only tested the performance outcome relationship based on a single examination, in our study we expect not only to collect more grades from students PL efforts, but also possibly to identify differences in grades as the semester progresses.

H5: Students with higher performance outcomes will perceive a higher degree of enjoyment from the PL approach

5.5.4 Perceived Learning (H6, H7)

Perceived learning is an intervening variable that displays the degree of learning students believe they have attained from participating in the PL approach. We argue that students who report higher measures of perceived learning will have actually learned more and thus have increased measures of critical thinking. This will be an important hypothesis in our study as students will be participating in the PL approach more than in the original study by Wu, Hiltz, and Bieber as students utilize the PL approach for multiple assignments throughout the semester. Therefore, we formulate the following hypothesis:

H6: Students with higher perceived learning will have higher actual learning (critical thinking) measures.

In addition, we believe that measures of perceived learning will be correlated to the students' recommendation for use of the system. We hypothesize that students who believe they have learned more will also be more positive towards recommending the approach. In the adapted PL approach model from Wu, Hiltz, and Bieber [2], recommendation for use substitutes for "behavioral intention." In this adapted model, it was argued that the strongest predictor for the recommendation for use was Performance Expectancy which is linked to Perceived Learning. Perceived learning plays an important role in our study as the students' learning perceptions are influenced by their participation in the PL approach for their course assignments throughout the semester. Therefore, we hypothesize the following:

H7: Students with higher perceived learning will be more likely to recommend the approach

5.5.5 Perceived Enjoyment (H8, H9)

Based on the extended model by Wu, Hiltz, and Bieber [2] , "Perceived Enjoyment" is seen as a substitute for "Perceived Ease of Use" in the TAM and UTAUT models to reflect intrinsic motivation. In our model, perceived enjoyment is represented as a combination of perceived flexibility, perceived pressure, perceived anonymity, perceived facilitation of process by the PL site, perceived degree of motivation and perceived overall enjoyment. However, given that the system is new and students have not previously been familiarized with it, we believe that how well the system runs will affect the students' overall perceived enjoyment as well. This is especially important as the students interact with the newly developed system throughout the semester so issues that come up will certainly leave an impression and affect the students greatly. We argue that students with a higher degree of perceived enjoyment will be more motivated to engage in the assignments, leading them to have a higher degree of perceived learning.

H8: Students with higher perceived enjoyment will have higher perceived learning

In addition, as described in the model by Wu, Hiltz, and Bieber [2], Perceived Ease of Use in the TAM has been found to lead to technology acceptance and thus higher chance of the PL approach being recommended to others. In the model, the construct Perceived ease of Use is part of the Perceived Enjoyment construct along other measures such as flexibility of the PL approach. As students end up enjoying the PL approach more, we believe that they will be more likely to recommend it.

H9: Students with higher perceived enjoyment will be more likely to recommend the PL approach

5.5.6 Actual Use (H10)

Given that the PL approach is a holistic approach to redesigning assignment participation where students take charge of their own learning, we argue that as students complete more PL assignments through the PL system and thus participate in a greater number of tasks, this will have a positive moderating effect on the relationship between perceived and actual learning as it would increase the students' critical thinking skills. As students complete more tasks using the PL approach, they will improve their own critical thinking as they engage in higher order thinking activities such as creating problems and evaluating other people's work on top of coming up with a solution.

H10: Increased measures of actual use will moderate the effect by strengthening the relationship between perceived learning and actual learning (critical thinking).

Finally, it should be noted that we do not evaluate any effect that Facilitating Conditions and Effort Expectancy might have on system use (Actual Use) because students do not have a choice of whether or not to participate in the PL approach and as such, student Actual Use is directly affected by the instructors' decisions on how to integrate the PL approach into their courses.

5.6 Summary

This chapter begins by describing the Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology. I then discussed the PL model that extends the work on Wu, Hiltz and Bieber, and further define the PL model variables and data collection method. Finally, I discuss the model in terms of its hypotheses and further describe how my work will test and extend on the Wu, Hiltz and Bieber model by a) retesting the current hypotheses applied to assignments and b) test the new hypotheses for actual use and critical thinking. In the Chapter 6 I will provide preliminary results from the pilot study by evaluating the PL system and exploring the research questions outline in Chapter 1. In Chapter 7, I further explore the research questions more deeply by collecting repeated measures throughout the semester while also exploring an additional condition (microlearning).

CHAPTER 6

PILOT (PRELIMINARY) PARTICIPATORY LEARNING STUDY

The purpose of this chapter is to describe the methodology and results from a preliminary study done about the PL approach. It should be noted that the main purpose of the study is not to draw conclusions trying to answer main research questions but instead serve as an exploration of the entire PL approach and system while testing it in a live environment. Through the preliminary study, we were able to test the system, the instruments and our methodology to inform our main dissertation study. The changes between the preliminary and main dissertation study are outlined in Chapter 7.

6.1 Pilot (Preliminary) PL Study Introduction

The PL approach and system has been worked on for several years. Initially, we contacted instructors at New Jersey Institute of Technology (NJIT) to trial the newly developed system and also test the PL approach so that we could get early feedback to further improve it. This early testing was not part of the preliminary study but served to prepare the system for it. Once we felt confident in the PL system and approach, I conducted a preliminary study to test the instruments but also formally evaluate the PL system throughout multiple semesters in both NJIT and also at Fairleigh Dickinson University (FDU).

From Spring 2018 to Fall 2019, I conducted a series of pilot studies in three courses at two universities. This preliminary study involved 18 total sections where 7 were control and 11 were treatment sections. During the pilot study, the instructors helped us to further develop and test the newly developed PL system in addition to also helping us create and test our instruments used to collect data. The pilot included STEM and non-STEM courses including engineering ethics (NJIT), Linux programming (NJIT) and an introductory spreadsheet course (FDU). In this study, my primary goal was to test the instruments but also to provide preliminary answers to some of the research questions outlined in Chapter 1 excluding questions that referred to microlearning.

6.1.1 Pilot Study Limitations and Focus

The focus of the pilot study was to a) evaluate the data collection instruments and b) test the PL system in actual classes to explore issues with the websites. There are several confounding effects that must be acknowledged and that can frame the results in further sections:

1. Possible instructor effects: Due to varying needs of instructors and their need of PL to fit their course learning objectives, the number of PL assignments varied according to the course. As such, comparisons across treatment and control cannot be generalizable. However, as outlined previously, the primary goal was to explore the research questions.
2. Possible incentive effects: Students could not be forced to participate in the study nor do the surveys. During the study, if students did not get an incentive they usually did not do the surveys nor the interviews. For example, for the interviews, it was usually difficult to get more than 10 students each semester and through the extra credit incentives we were able to collect qualitative data on them.
3. Differences in the number of PL tasks (for the treatment conditions): Similar to the instructor effect, the differences in the number of PL tasks arose for the need to fit into the instructors course learning objectives. Nevertheless, in the model presented the number assignments was account for a mediator variable to determine the strength of the relationship between perceived and actual learning.

6.1.2 Pilot Study Research Questions

The following are the research questions that were explored in the pilot study.

1. Main Research Question #1: How does the PL approach affect the students in the course when applied to assignments?

- Sub-question #1.1: Do students enjoy their learning experience in the Participatory Learning approach for assignments?
- Sub-question #1.2: Do students perceive learning in the Participatory Learning approach for assignments?
- Sub-question #1.3: Do students perceive learning from each aspect of the PL approach for assignments? (i.e., create problem, provide solution, grade others, viewing others' work)
- Sub-question #1.4: Would students recommend using the PL approach for their assignments?

2. Main Research Question #2: Do the hypotheses in the model used by Wu, Hiltz, and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?
    - Sub-question #1.1: Do all hypotheses in the original model hold true for assignments?
    - Sub-question #1.2: How can I extend the Wu, Hiltz, and Bieber theoretical model to account for actual learning (critical thinking) and system use?
3. Main Research Question #3: Are there any significant differences in the effect in enjoyment, learning and critical thinking between students who experienced the PL approach and those who did not?
    - Sub-question #3.1: Are there any significant differences in perceived enjoyment between students who experienced and those who did not experience the PL approach?
    - Sub-question #3.2: Are there any significant differences in perceived learning between students who experienced and those who did not experience the PL approach?
    - Sub-question #3.3: Do students who participate in the PL approach improve their critical thinking skills when compared to those who do not participate?

6.1.3 Pilot Study Methodology

In this sub-chapter I will describe the methodology of the pilot study.

Instructors that participated in the study worked directly with me to create PL assignments that were based on the assignments they were already giving to students. For recruitment, it was important to have instructors who had multiple sections where we could have a control and at least one treatment section. As part of the study, instructors agreed to the following:

1. Instructors ran control and treatment sections whenever possible. Some courses did not have paired sections to work with but still helped us test the system and questions for our preliminary study.
2. Instructors created at least one PL assignment to be given to students.
3. Instructors worked with the research team to create a critical thinking question to be given to all students at the end of the semester based on Facione’s IDEALS critical thinking process framework [87]. An example of a critical thinking question is in Appendix B.1.
4. Instructors agreed to granting extra credit to students who participated in the survey (and in some cases in the interview) studies. In general, extra credit was between 1 to 3 final grade points depending on the number of surveys completed.

To improve recruitment for the pilot, I needed to be flexible with the instructors to accommodate to their course needs as instructors needed different ways to implement the PL approach to meet their course learning objectives (flexibility is an important aspect of the approach). Therefore, the numbers of assignments and sections were not always similar across courses. The amount of extra credit varied across courses depending on the instructor. Finally, due to IRB limitations, while the PL assignments were mandatory, I could not force the students to participate in the study and therefore it was not possible to get a complete dataset from the entire class as students needed to provide consent to access the grades and also complete the surveys. (The study actually comprised only the analysis of the PL approach using surveys, interviews and the consented student data, and did not technically include the assignments. Therefore, the PL assignments were mandatory as they were the pedagogic choice of the instructor for how he or she structured the course sections.)

The control section of the course served as a baseline that was used to compare the effectiveness of the treatment section. Students in the control group had regular class meetings including face to face or distance learning. The assignments given to the students were similar to the assignments given to the treatment groups. To ensure similarity, whenever possible, we converted the regular assignments in the control section to a participatory learning form. In the control section, the instructor was in charge of handling the traditional tasks such as creating a problem and grading the students' solutions. In addition, students were allowed to use the resources available to the course such as Moodle, Blackboard, Canvas, or any other software relevant to their course. There was no change in the teaching dynamics nor in how the regular assignments and exams were administered. However, students were surveyed and evaluated to determine their satisfaction with the course (survey), perceived learning (survey) and actual learning through a quiz or exam given at the end of the semester that tests critical thinking aspects.

For the treatment section, students had the same class recitation material given to the control group. In addition, students in the treatment groups were also allowed to use the resources available to the control group such as Moodle, Blackboard, Canvas, or any other relevant software. Nevertheless, the treatment groups also used the PL system for their assignments. I worked with the instructors to agree on a specific number of PL assignments to give throughout the semester, create the instructions for the PL assignments, and then implement them into the system.

For PL assignments in the treatment section, students participated throughout the entire assignment process which included a combination of 1) creating a question (except for CS 288), 2) developing a solution, and 3) grading peers. Additional tasks included revisions to work submitted, and self-assessment tasks that allowed students to dispute their grade when needed.

Participants in the treatment group completed a single survey at the end of the semester which included the same questions as the control group to account for their satisfaction with the course (survey), perceived learning (survey), and actual learning However, the surveys for participants in the treatment group also collected measures related to their use of the PL system including perceived learning from use, satisfaction with the system, perceived enjoyment and recommendations.

Participants reported in the next section do not represent all the students who were part of the PL study but rather only students who were part of the PL study and agreed to have their information collected. The data collected throughout the pilot study was analyzed quantitatively using SPSS and SmartPLS software, and qualitatively using MAXQDA.

6.1.4 Pilot Study Participants' Description

As mentioned above, the pilot study involved 18 total sections where 7 were control and 11 were treatment sections, from Spring 2018 to Fall 2019. When reporting our findings below, we have substituted for the name of the Professor with a pseudonym. There were four instructors, so we used Alpha, Bravo, Charlie and Delta as a pseudonym for them. Nevertheless, given the degree of details provided to explain the course characteristics, there is a significant chance for the instructors to be identified. The summary of the students in each course is described in Table B.1.

One course was taught by Professor Alpha at New Jersey Institute of Technology. The course title was "PHIL 334 - Engineering Ethics and Technological Practice:

Philosophical Perspectives on Engineering." We ran treatment and control sections in Spring 2018, Fall 2018 and Spring 2019. In Spring 2018, Professor Alpha had one control section (45 students), and two treatment sections (48 and 23 students). In Fall 2018, Professor Alpha had one control (38 students) and one treatment (19 students). In Spring 2019, Professor Alpha had one control (42 students) and one treatment (36 students).

A second course was taught by Professor Bravo at New Jersey Institute of Technology. The course title was "CS 288 - Intensive Programming in Linux CS288." We ran a pilot with a single treatment section in Fall 2019 and no control section. In Spring 2019, Professor Bravo ran a test in his class but it was not counted in the main study due to issues with the data including the lack of a critical question due to logistical issues during the semester. In Fall 2019, Professor Bravo ran a single treatment section (61 students). It should be noted that while in other sections students were able to participate in the three major assignment tasks (create problem, create solution, grade solution), for this course students were not able to participate in the create problem stage due to how the assignment was set up by the instructor.

The last course that was part of our pilot study was taught by Professor Charlie and Professor Delta (each one had separate sections) at Fairleigh Dickinson University. The course title was "MIS 1045 – Information Technology for Business." We ran studies in Fall 2018 and Fall 2019. Both Professor Charlie and Professor Delta ran treatment and control sections during both semesters. In Fall 2018, Professor Charlie had one control section (19 students), and one treatment section (20 students). In Fall 2019, Professor Charlie had one control (10 students) and three treatments (14, 14, and 17 students respectively). In Fall 2018, Professor Delta had one control section (17 students), and one treatment section (17 students). In Fall 2019, Professor Delta had one control (14 students) and one treatment section (20 students). Information for each course grade divided by section can be found in Tables B.2, B.3, B.4 and B.5.

Overall, in this pilot study, the total number of participants (N) was 474. Our treatment had 185 participants and our control had 289 participants. Students received extra credit for participating in the study (i.e., completing the surveys and doing interviews). However, due to IRB requirements, students could opt out of the study if they desired to do so. For the interviews, participation was voluntary by students who received extra credit for participating in them. In the control, 42 (22.7%) participants were female and 141 (76.2%) participants were male. In our treatment, 62 (21.4%) were female and 223 (77.2%) were males. Two participants in our control and two participants in our treatment answered "Other" gender. Two participants in the treatment study preferred not to provide an answer. In Appendix B Tables B.6, B.7, B.8 and B.9, we provide additional descriptive statistics for each instructor by semester. These tables contain the average course grade, PL grades, and gender distribution.

About the participants' primary language, 43 (23.2%) in our control and 74 (25.5%) in the treatment group responded that English was not their first language. Although the number of ESL students seems relatively high, this is expected as NJIT is a multi-cultural university with a sizable international student body. In the dissertation, the analysis of the student's main language will separate students from each institution.

Haven taken an online course before might have made students more comfortable using the online PL system. It is observed that 5 (2.7%) of the students in the control section and 8 (2.8%) of the students in the treatment section had no experience taking an online course before. While some courses were face to face, the PL system ultimately were online and as such knowing how many courses they have taken could describe a certain degree of experience working on coursework online that we use to compare the demographics of the conditions. In addition, about 110 (59.5%) of the students in the control section and 171 (59.2%) of the students in the treatment section had experience taking five or more online courses. Due to the percentages being relatively close for both control and treatment sections, this means that most of the students, regardless of condition, were used to being part of an online course, but more importantly, there was no difference in this prior experience between treatment and control conditions in the Pilot. Additional details can be seen in Table B.10.

6.2 PL Pilot (Preliminary) Data Description

In this section, I will report the results from the study in two parts. First, I will describe the results relevant to the PL approach which were collected only from the treatment section. These results include questions specific to the PL system and approach such as the System Usability Scale to assess the usability of the PL system, and direct questions regarding the PL assignments including their thoughts on creating questions and solutions, and the ability to grade each other. In the second part, I will report results that compare data that was collected for comparison purposes across the treatment and control sections. In section 6.3, the results are framed to explain the research questions. The majority of the questions in the pilot study used a 5-item Likert scale for agreement (strongly disagree: strongly agree) so the data collected was ordinal. Data from the System Usability Scale and CAP survey were numeric. Data related to the course grades was numeric as well.

To further explain the statistical test used in the following subsections, the Chi-square test requires two assumptions. The first assumption is that the two variables are measured at the ordinal or nominal level and the second assumption is that the data consist of two or more independent groups. Therefore, these two assumptions were met since the data collected comes from two different independent sections and as explained before is ordinal due to the use of the Likert scale. Because this is a non-parametric test, the assumption of normality was not needed.

Finally, as mentioned initially, I also used a t-test for numeric variables that included the following: course grade, critical question grade, CAP cognitive score, and CAP Affective score. An issue I had with the critical question grade was that one professor was harsh on grading and gave students very low grades, which led to a very skewed distribution for the critical thinking grades.

6.2.1 Data Results Related to the PL Approach and System

The data in this section was ordinal data collected through the use of a Likert Scale with values from 1 to 5. The data has been grouped by the major construct each one aimed to provide additional information about. These include Facilitating Conditions, Effort Expectancy, Perceived Enjoyment, Perceived Learning and Recommendation for Use.

Facilitating Conditions: With respect to the PL approach, the data indicates that 72.7% agreed or strongly agreed that the instructions for "problem and solutions" were explicit enough (Mean = 3.99, SD = 0.97). 73.7% of the students agreed or strongly agreed that the "grading criteria and guidelines" were explicit enough (Mean = 4.06, SD = 0.93). For our study, having high measures of clarity is important as we want the process to be clear for the students and thus having clear instructions helps. With respect to fairness, we observe something interesting. Even though 69.6% of the students did agree or strongly agree that the grading process was fair (Mean = 3.95, SD = 0.95), only 41.8% of the respondents believed that students were capable of grading the solutions of the problems they designed. This is an interesting finding as it shows some disconnect between grading fairness and student perception of others' ability to grade. The perception of grade fairness is important for our study as it will feed into students' perceived enjoyment by directly affecting students' motivation. Also, for the main dissertation study, it would thus be important for us to continue providing clear instructions and rubrics to students while also providing them with training on how to evaluate others. In reference to the instructor evaluation, 67.5% of the students believed that the instructor coordinated the PL approach well (Mean =3.86, SD = 1.12) and 68.9% rated satisfactory or highly satisfactory the degree of help the instructor provided (Mean = 3.91, SD = 1.21). (See Table B.11.)

Effort Expectancy: When comparing the opinion students had with respect to the level of difficulty expected of the course and their perception of difficulty after taking it, we observed that overall 45% expected the course to be difficult (Mean = 3.298, SD = 1.24) and 44.3% actually found it difficult (Mean = 3.33, SD = 1.21). The small change in difficulty gives us an indication that there does not appear to be an increase in perceived difficulty from the initial set of expectations formed by the students. However, these two measures were taken at the same time near the end of the semester and thus the students' expectations may not have actually reflected that and may have been different if the measure of expected difficulty would have taken at the beginning of the semester. The difficulty of the course was further manifested in the students' responses on expected grades as there was a marked majority of people (62.7%) who thought they had performed well in the course by achieving a B+ or higher. (See Tables B.12 and B.13.)

Perceived enjoyment: With relation with perceived enjoyment, system usability was an important factor to consider. We present the distribution of the ten questions that make up the System Usability Scale. 45% of the students thought they would like to use this system frequently and only 27% would not. 46.7% did not find the system unnecessarily complex. Whereas 54.6% thought the system was easy to use, 23.6% disagreed. Also, 20.7% believe that they would need the support of technical person to use the website. 33.9% thought that there was too much inconsistency with the website whereas 43.2% disagreed. 57.4% of the students thought that they would be able to learn to use the site quickly and 29% found the system cumbersome to use. 55.1% felt very confident about using the system while only 19% disagreed. Finally, 23.2% of students agreed that they needed to learn a lot before using the system while 49.5% disagreed. However, the SUS score based on the ten questions collected showed a mean score of 59.56 with a standard deviation of 19.88. Unfortunately, this mean score places the PL system below the average score of 68 in other systems [90]. 59.9% of the students agreed that they enjoyed the flexibility that the PL approach provided (Mean =3.69, SD =1.11) which was important as having a positive perception tended to improve the student perceived enjoyment. 67.5% of students believed that the time allowed for the PL assignments was sufficient (Mean = 3.85, SD = 1.16) and 29.4% agreed that they felt under pressure doing the assignments using the PL approach (Mean = 2.813, SD =1.22). Therefore, we conclude that students felt positive about the flexibility the PL approach provided which should positively affect students' perceived enjoyment as well. Perceived anonymity was one of our most positive measures with 72.7% of students agreeing to feeling positive about other students not knowing their identities (Mean = 4.15, SD = 1.09). 43.5% agreed that they feel under much pressure doing the assignments in this way. Students felt relatively positive about the PL system helping facilitate the PL approach with a mean score of 3.47 and standard deviation of 1.09. Students expressed positive measures of motivation related to being stimulated to do additional reading (Mean = 3.63, SD =1.24), being motivated to their best (Mean = 4.00, SD = 1.03) and overall being motivated in the course (Mean = 3.78, SD = 1.17). Having positive measures of motivation is important as they also help increase the students' perceived enjoyment. Finally, the students were positive towards enjoying the course (Mean 3.83, SD =1.21). (See Tables B.14a, Table B.14b, Table B.14c.)

Perceived Learning: Regarding perceived learning, we used the CAP Survey to measure perceived cognitive and affective learning. In relation to perceived cognitive learning, students' mean score was 11.81 with a standard deviation of 3.03. In relation to perceived affective learning, students' mean score was 12.13 with a standard deviation of 3.9. For each scale, the minimum score was 0 and maximum was 18. Therefore, there did not appear to be any initial indication of students in the treatment condition having increased measures of perceived learning.

However, students seemed to have slight positive measures of perceived learning from making up problems (Mean = 3.85, SD =1.016), solving problems (Mean = 3.65, SD = 1.06), grading others (Mean =3.66, SD = 1.22), reading others' work (Mean = 3.86, SD = 1.15). In addition, students believed that the PL approach allowed them to demonstrate what they learned in the course (Mean =3.88, SD = 1.08), and caused them to synthetize different things they knew (Mean = 3.80, SD = 1.05). On the other hand, an interesting measure was that whereas 25.9% agreed that students were not able to design good problems, only 41.2% thought students were able to design good problems with the mean score being closer to the average. Thus, guidance when creating a problem will be important for the study as to improve the quality of the problems created.

Overall, most students believed that the PL approach helped them learn more (Mean = 3.49, SD = 1.15). Having positive measures of learning was important because it helped us determine whether students believed that the PL approach helped them learn more. (See Table B.15a and Table B.15b.)

Recommendation for Use: Under the criteria of "recommendation of the system", while only 36.6% agree or strongly agree with the idea of using the PL approach for traditional assignments and 31.5% disagree or strongly disagreed (Mean = 3.06, SD = 1.21), the majority of students at 52.9% would recommend or strongly recommend in the future to use the PL approach in the course (Mean = 3.46, SD = 0.99). See Table B.16. There seems to be a disconnect between recommendation of the PL approach for assignments and recommendation of the PL approach for the course and assignments. Given the similar wording of the questions, this difference is unexpected and would merit further consideration. It should be noted that while similar scales were used, the wording of the scale was different for both questions as it used Strongly Disagree/Agree and Strongly Oppose/Recommend.

6.2.2 Data Results Comparing Treatment and Control Sections

Course Difficulty: On average, students in the treatment section expected the course to be harder (Mean = 3.29, SD = 1.24) than the control section (Mean = 2.83, SD = 1.18). This difference is significant (Chi-square = 22.4, P = 0.000). We can attribute this to the expectations students form at the beginning of the semester as they are told they were told that they were going to use a new approach while also using a new system other than Moodle or Canvas that they have become accustomed to. See Table B.17. It should be noted that in ideal conditions, we would have asked this question at the beginning of the semester rather than at the end of the semester and thus updated when this question was asked in the dissertation study. On average, students in the treatment section found the course to be more difficult (Mean = 3.33, SD = 1.21) than the control section (Mean = 2.95, SD = 1.12). This difference is significant (Chi-square = 14.7, P = 0.005). We could thus hypothesize about this significant difference being due to 1) expectations students formed at the beginning, and 2) students' own perceptions changing after engaging in the PL approach using the newly developed system. (See Table B.18.) This was continued to be studied in the main dissertation study in which the measures for how difficult the students expected the course to be and how difficult they found the course to be were collected at the beginning and end of the semester respectively. This would also allow us to determine why 86.5% of students in the control group expected to get B or better, while 77.3% of students in the treatment group expected the same, thus indicating that students in the treatment section expected lower grades as shown in Table B.19.

Perceived Learning Interaction: In terms of learning, students in the control section tended to slightly favor interaction with students rather than passively listening to the instructor's lecturing (Mean = 3.55, SD = 1.19). Similar results were found in the control section (Mean = 3.55, SD = 1.13). There are not significant differences according to the Chi-square test (Chi-square = 1.6, P = 0.81). While we expected students in the treatment section to have higher agreement towards learning more from interacting with students, to determine whether the PL approach affects students' perceptions regarding learning from interacting with other students we would need to collect measures at different points in semester. (See Table B.20.) Another important analysis would be whether students who favored learning with others would be more likely to positively react to the PL approach rather than those who do not. This can be further explored as well.

Students in the control section tended to slightly favor interaction with students rather working on their own (Mean = 3.44, SD = 1.22). Similar results were found in the treatment section (Mean = 3.45, SD = 1.16). There are not significant differences according to the Chi-square test (Chi-square= 1.54, P = 0.82). While we also expected students in the treatment section to have higher agreement towards learning more from interacting with students, to determine whether the PL approach affects students' perceptions regarding learning from interacting with other students rather than working on their own, we would also need to collect measures at different points in semester. (See Table B.21.)

Course Educational Value: Students were also asked about their evaluation of the overall educational value of the course. Overall, both treatment and control conditions were satisfied with the value of the course.

Positive results were found in the control condition in terms of course value satisfaction (Mean = 4.28, SD = 0.88). Similar results were found in the treatment section as well (Mean = 4.11, SD = 1.02). There does not appear to be any significant differences between treatment and control according to the Chi-square test (Chi-square= 6.36, P = 0.17). While we expected the treatment section to have added educational value from participating in the PL approach and thus be greater than the control, it does not seem that this was the case. However, the number of PL assignments and tasks could potentially be an important factor to consider in the future as well. (See Table B.22.)

Instructor Teaching Ability Evaluation: Students were also asked about their perception of the overall teaching ability of the instructor. While both control and treatment had positive views about the instructors' abilities, the control condition (Mean = 4.3, SD = 0.93) had a greater positive response than the treatment condition (Mean = 3.90, SD = 1.21). In addition, there are significant differences between control and treatment conditions according to the Chi-square test (Chi-square = 14.72, P = 0.005). Therefore, it would merit some additional research in determining whether students' expectations about the instructors' teaching ability changed due to the PL approach. (See Table B.23.)

Overall Course Evaluation: Finally, the evaluation of the course was overall satisfactory and slightly in favor of the control condition (Mean = 4.13, SD = 0.88) when compared to the treatment condition (Mean = 4.04, SD = 0.97). The chi-square value was 2.219 and P value was 0.70 so the differences did not appear to be significant at the 0.05 significance level. Nevertheless, the chi-square test had some issues as some cells had a count of less than 5. (See Table B.24.)

Critical Thinking Skills: Regarding the perceived learning category, 149 (80.5%) students of the control group felt their skill in critical thinking to solve problems had increased during this course. In our treatment group, there were 212 (73.4%) students who shared the same idea. However, upon further comparison, the control condition (Mean = 4.06, SD = 0.97) and the treatment condition (Mean = 4.00, SD = 0.98) had relatively equal mean scores. There also are no significant differences between control and treatment (Chi-

Square = 6.14, P = 0.18). Therefore, according to the Chi test, students didn't perceive any change to their critical thinking skills. (See Table B.25.)

Reading Comprehension: In the study, 147 (79.5%) of the students in the control group felt that their ability to comprehend information has increased. Meanwhile, in the treatment group this number was 219 (75.8%). Upon further comparison, the control condition (Mean = 4.070, SD = 0.93) and the treatment condition (Mean = 4.05, SD = 0.94) had relatively equal mean scores as well. There were not significant differences between control and treatment (Chi-Square = 2.65, P = 0.62). As with critical thinking, there were not any changes in how they perceived to comprehend information between treatment and control. (See Table B.26.)

Problem Solving and Justification: There were 147 (79.5%) students in the control group who believed that their ability to articulate and write a well thought out solution has increased, and for the treatment group this number was 201 (69.6%). Upon further comparison, the control condition (Mean = 4.08, SD = 0.98) had higher mean score than the treatment condition (Mean = 3.88, SD =1.00). Although there seemed to be a slight difference, this difference was not significant (Chi-Square = 7.79, P = 0.10) at 0.05 significant level. This slight decrease in students' perception on writing a well thought out solution in the treatment section could be attributed to students not fully understanding the problems created by other students and thus we should seek to provide additional guidance and clarity. (See Table B.27.)

Integrate Facts and Generalization: 145 (78.4%) of the students in the control condition agreed or strongly agreed that their ability to integrate facts and develop generalizations improved when compared to 204 (70.6%) in the treatment condition. Upon further comparison, control (Mean = 4.05, SD = 0.91) has greater scores than the treatment condition (Mean = 3.92, 0.97). However, this difference appears to not be significant (Chi-Square = 6.58, P = 0.16). (See Table B.28.)

Stimulation to do Additional Reading: 116 (62.7%) students in the control group stated that during this course they were stimulated to do additional reading, and for the treatment group this number was 167 (57.8%). Upon further comparison, the control condition (Mean = 3.72, SD = 1.19) had higher mean score than the treatment condition (Mean = 3.63, SD = 1.24). Although there seemed to be a slight difference, this difference was not significant (Chi-Square = 1.76, P = 0.78) at 0.05 significance level. While not significant, this slight decrease in students' perception in motivation to do additional reading is similar to previous results in which the control section seemed to get better measures. Thus, it would be worth further investigating in the dissertation with the help of additional repeated measures and a more varied array of courses in the study. (See Table B.29.)

Value Others Point of View: One important highlight of the results in this study was related to whether students considered that during the course they learned to value other points of view. We expected this opinion to be higher in the treatment condition as a consequence of using the system to work with other students by giving feedback and assessing them. Nevertheless, the data indicated that 143 students (77.3%) in the control condition considered that they learned to value other points of view. Meanwhile, this number was 184 (63.6 %) for the treatment group. (See Table B.30.) When further comparing the means for both conditions, the control condition (Mean = 4.04, SD = 1.03) was higher than the treatment condition (Mean = 3.79, SD = 1.21). A likely explanation was that according to the students' feedback, they perceived their peers did not do a better job than the teaching assistants and the instructor while grading and providing feedback and thus their overall experience might not have been great. This student concern may have been further exacerbated if we consider students had to wait until the last minute to challenge their grade if their peers waited to the last minute to grade the assignment, creating waiting queues to hear back from disputing their grades with the instructors. It should be noted that this difference was significant (Chi-square = 12.02, P = 0.02) at 0.05 significance level.

Motivation: About motivation, for the control condition students indicated that they were slightly more motivated than the treatment section. For example, 148(80%) of the students in the control section indicated that they were motivated to do their best work while in the treatment condition only 213 (73.7%) of the students indicated the same. However, this difference was not significant (Chi-square = 6.53, P = 0.16) at 0.05 significance level. Similar results were indicated when 190 (76.2%) students in the control (Mean = 4.03, SD = 1.02) condition indicated that they were more motivated in the course when compared to 190 (65.8%) students in the treatment condition who agreed as well (Mean = 3.72, SD = 1.17). In addition, the differences were also not significant (Chi-square = 6.61, P = 0.16) as well. Overall, this would merit further study to be able to determine the factors influencing these results, such as issues with the clarity of the process, the website they are using or even lack of enough PL assignments. (See Tables B.31 and B32.)

Course Enjoyment and Learning: Regarding enjoyment in the course, 141 (76.3%) of the students in the control condition (Mean = 4.21, SD=1.04) agreed that they enjoyed the course whereas only 196 (67.5%) did in the treatment condition (Mean = 3.83, SD =

1.22). This difference was significant (Chi-square = 15.51, P = 0.004) at 0.05 significance level. Lower perceptions of enjoyment are bound to potentially negatively affect students' perceived learning and also recommendation of the approach. Therefore, in the man dissertation study it will be important to help students through training, demonstration and troubleshooting so that the process is better received. In fact, 164 (88.7%) of the students in the control group (Mean = 4.50, SD = 0.80) felt that they learned a lot in this course, whereas only 227 (78.6%) did in the treatment group (Mean = 3.83, SD = 1.22). This difference was significant (Chi-square = 17.69, P = 0.001) at the 0.05 significance level. This is also an important finding that should be further explored in the dissertation study. (See Tables B.33 and B.34.)

6.3 PL Pilot (Preliminary) Research Questions

In this pilot study I explored and provided preliminary results for the Main Research Question #1, #2 and #3 without taking into account questions related to microlearning.

6.3.1 Main Research Question #1

For Main Research Question #1, I asked: "How does the PL approach affect the students in the course when applied to assignments?" Thus, it was important to evaluate how the PL approach affected students' perceived learning at each stage of the assignment and if they would recommend it. To answer this, I explored the following main sub-questions.

Sub-question #1.1: Do students enjoy their learning experience in the Participatory Learning approach for assignments?

Based on the data presented, students in the treatment condition overall had a positive attitude towards the PL approach and enjoyed multiple aspects of it. While only

54.3% of students enjoyed the PL approach, this represents the majority of students. Regarding the PL system, while only 49.3% of students believed that the website made the approach easier, the mean score was 3.47 and thus students seemed to have an overall positive attitude about the system. Nevertheless, we believe that students' enjoyment of the PL approach could be further improved by training students through demonstrations in class or online, clearer instructions and better information provided to them. Thus, regarding RQ1.1**, I can state that most students enjoyed being part of the Participatory Learning approach for assignments.**

Sub-question #1.2: Do students perceive learning in the Participatory Learning approach for assignments?

Based on the data presented, students in the treatment condition overall had a positive attitude towards the PL approach and perceived that it helped them learn more. 55.4% of the students believed that the PL approach helped them learn more and 78.6% of students agreed with that idea that they have learned a lot in the course. Therefore, regarding RQ1.2**, I can state that most students perceived learning benefits from being part of the Participatory Learning approach for assignments.**

Sub-question #1.3: Do students perceive learning from each aspect of the PL approach for assignments? (i.e., create problem, provide solution, grade others, viewing others' work)

Based on the data presented, students in the treatment condition overall seemed to have a positive attitude towards the PL approach and perceived that each aspect helped them learn. Students seemed to have higher measures of perceived learning from making up problems and seeing others' work. As we continue using PL in a broader array of courses, it would be interesting to determine whether STEM and non-STEM courses have different perceived measures of learning with respect to each aspect of their assignment process. When comparing RQ2 and RQ3 results, we notice that both relate to perceived learning. While overall students were positive about the perceived learning benefits of the PL approach, it seemed that they perceived the individual parts of the assignments being more positive towards the creative aspect of problem creation and also the ability to review others work. Our qualitative study results will provide us with more context about these results, for example, students in a programming course had very positive responses towards the ability to review the source code developed by other students. Therefore, regarding **RQ1.3, I can state that the majority of the students who participated in the PL approach agreed to have learned from each aspect of the PL approach used for their assignments.**

Sub-question #1.4: Would students recommend using the PL approach for their assignments?

I asked two questions to students regarding their recommendation of the PL approach. First, we asked students if they would rather use PL for assignments instead of the traditional approach. 36.6% of the students agreed or strongly agreed with that statement, 31.8% remained neutral and 31.5% disagreed or strongly disagreed. The mean score for this question was 3.06 and standard deviation was 1.21. However, when I directly asked if students would recommend in the future that the PL approach be used for the course and its assignments, students were more receptive of the idea. 52.9% of students who participated in the treatment section recommend or strongly recommended that the PL be used in the future for assignments, 31.1% remained neutral and 15.9 opposed or strongly opposed with the idea. Thus, it appears that there might be some disconnect between both questions that needed further exploration**. Therefore, due to the lack of clarity in the results, I was not able to answer RQ1.4 and instead further research was needed.**

6.3.2 Main Research Question #2

For Main Research Question #2, I asked: “Do the hypotheses in the model used by Wu, Hiltz, and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?” Thus, it was important to not only evaluate the model by Wu, Hiltz and Bieber [2] in the context of assignments but also evaluate new hypotheses proposed. As mentioned in the Chapter 5, The following PL model hypotheses do not test the research questions outlined in Chapter 1 but rather test relationships in the PL model. To answer RQ#2, I explored the following main sub-questions.

Sub-question #2.1: Do all hypotheses in the original model hold true for assignments?

To analyze the data for the PL model, I used SmartPLS software. I utilized Partial Least Squares (PLS) analysis which is commonly used in Information Systems research. I utilized SmartPLS to assess the internal consistency and discriminant validity of the constructs. Regarding the data used and normality, PLS does not impose normality requirements on the data [91].

Measures calculated include Composite Reliability and Square Root of Average Values Extracted (AVE). Composite Reliability (CR), which is a measure of internal consistency in scale items similar to Cronbach's alpha, that determines how closely related as a group a set of items are. This means, that the items in the group reflect measures of the same underlying construct. Thus, we want to have items that affect the construct to be related in some way so that we have a more consistent measure. All Composite Reliability scores exceeded 0.7 and all AVE's exceed 0.50 based upon the Fornell and Larcker's recommended criteria [92], [93]. (See Table B.35.)

In addition, I conducted a Factor Analysis study using the Partial Least Squares (PLS) method on SmartPLS to determine the Item Loadings, and Standard Error. The results are presented in Table B.36a, B.36b and B.37. For items loadings, all but one of our constructs (Item loading "CAP Cognitive" = 0.597) in Table B.36b exceeded the item loading threshold of 0.60. Item loading refers to how much of the change in the construct is explained (or contributed) by the individual item. It should be noted if the construct only had a single item, its item loading will be 1.0 because that single item will account for all the change in the construct. For example, for Actual Learning which had a CR of 1, we only used a single critical thinking score so it had a CR of 1 as it only had a single item which had an item loading of 1 as well. This also applies to actual use, effort expectancy, performance outcome and recommendation for use. From Table B.36a and B.36b, we can see that Facilitating Conditions (CR= 0.82), Perceived Enjoyment (CR=0.86) and Perceived Learning (CR=0.88) had high Consistent Reliability, which tell us that the set of questions and/or measures taken for each construct respectively were closely related as a group.

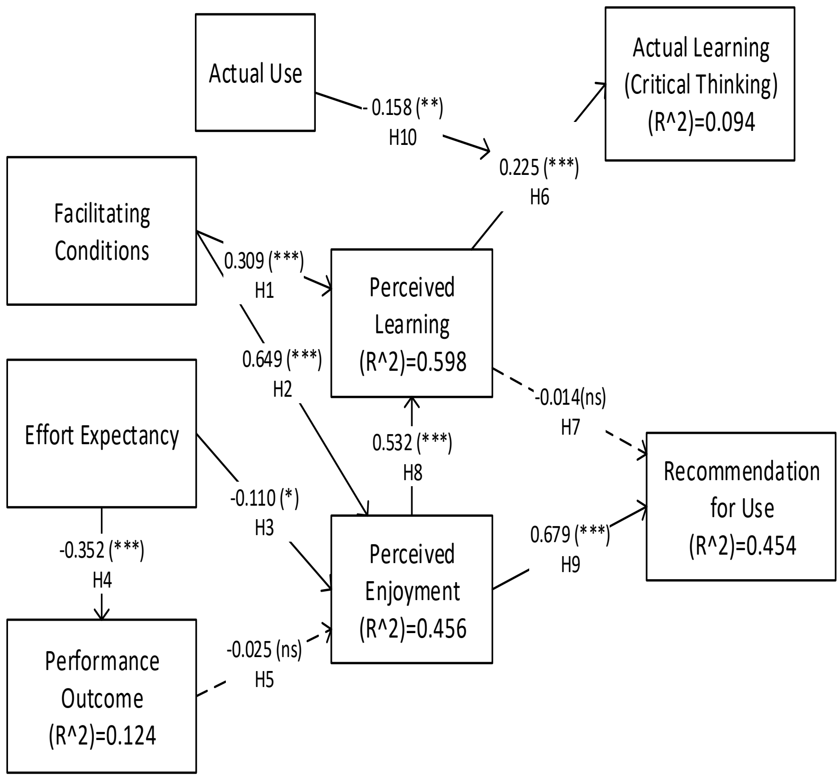


Figure 6.1 PL model pilot results.
0.05 = *, 0.01 = **, 0.001= ***, ns = non-significant
Note: Inside the connecting arrows we show the β value known as the path coefficient.
Note2: The H10 arrow indicates a moderating effect in the relation between Perceived Learning and Critical Thinking.

The hypotheses for the model were tested using a bootstrap method with 1000 samples using SmartPLS3 PLS-Path analysis. The model was able to account for a sizable variance on Perceived Learning (R = 0.598), Perceived Enjoyment (R = 0.456) and Recommendation for Use (R = 0.454). To a lesser degree, the model also accounted for much smaller variances on Performance Outcome (R = 0.124) and Actual Learning (R = 0.094). In the model in Figure 6.1, significant relationships will be accounted for by using solid lines, and non-significant relationships use a dotted line. A description of each hypothesis follows below.

H1: Students who perceived Improved facilitating conditions will perceive increased learning; and H2: Improved facilitating conditions lead to an increase in perceived enjoyment

As demonstrated in Figure 6.1, the majority of the hypothesized relationships between our constructs are supported with a significant level of confidence. Whereas the model by Wu, Hiltz and Bieber tested the modified acceptance model on participatory learning examinations, **I found similar significance measures for Facilitating Conditions (FC) for PL assignments. Therefore, H1 and H2 are not only significant but also strongly associated with Perceived Learning (β = 0.309) and Perceived Enjoyment (β = 0.649).** Thus, similar to the model results for examinations, for educational technology acceptance for assignments it is important to have clear instructions and positive perception on grading fairness. Thus, I can then generalize that for both assignments and examinations, facilitating conditions play an important role not only on student Perceived Learning (PL) but also on their Perceived Enjoyment (PE).

H3: Students who perceive a higher degree of effort expectancy will derive less enjoyment from the PL approach

Another similarity to the Wu, Hiltz, and Bieber study is that Effort Expectancy (EE) was negatively associated (β = -0.110) with Perceived Enjoyment (PE) while having a significant relation, thus supporting (H3). This effect was not surprising as I expected that as students found the course more difficult, their Perceived Enjoyment (PE) decreased.

H4: Students who perceive a higher degree of effort expectancy will have lower performance outcomes.

Unlike the extended TAM model by Wu, Hiltz and Bieber that did not find a significant relationship between Effort Expectancy (EE) and Performance Outcome (PO), we did find a significant and negative association ($\beta = -0.352$) between Effort Expectancy (EE) and Performance Outcome (PO). Unlike the extended TAM model that was used with only examinations, I conducted multiple assignments throughout the semester and thus collected additional grading measures. **Students who found the course to be more difficult ended up scoring lower on the PL assignments and thus confirmed the significance of H4.**

H5: Students with higher performance outcomes will perceive a higher degree of enjoyment from the PL approach.

Another difference I found in our pilot was that for assignments, Performance Outcome (PO) did not lead to a significant association with Perceived Enjoyment (PE), **thus our hypothesis H5 was not significant.** This indicates that student enjoyment which included motivation remained the same regardless of whether or not the students thought the course was difficult. An important issue to consider was that students had difficulty finding their grades in the PL system (a future feature) and therefore they might not have been able to form their own opinions due to not knowing their assignment grades.

H7: Students with higher perceived learning will be more likely to recommend the approach.

Perceived Learning (PLe) needed additional work as it did not have a significant association with Recommendation for Use (H7). This would then be reviewed again in the main dissertation study as this relationship was one of the strongest in the original model along with all relationships between the constructs.

H8: Students with higher perceived enjoyment will have higher perceived learning.

Perceived Enjoyment (PE) had a significant positive association with Perceived Learning (PLe), and thus confirmed our hypothesis H8. Students with higher measures of PE ended up having higher measures of PLe ($\beta = 0.532$). Thus, students who felt motivated and overall enjoyed the approach, seemed to have greater measures of perceived learning.

H9: Students with higher perceived enjoyment will be more likely to recommend the approach.

I also confirmed that there was a significant and very positive association between Perceived Enjoyment (PE) and Recommendation for Use (RU) thus confirming our H9. The relation between PE and RU was positive with a $\beta = 0.679$, thus as students reported higher measures of perceived enjoyment, they would have been more likely to recommend the approach.

Sub-question #1.2: How can I extend the Wu, Hiltz, and Bieber theoretical model to account for actual learning (critical thinking) and system use?

H6: Students with higher perceived learning will have higher actual learning (critical thinking) measures.

Perceived Learning did have a positive association with Actual Learning (measured through a critical thinking question given to students) and indicated a significant relationship. However, β was 0.225 and R-square value was 0.094. In addition, the data for a single course did not seem to be evenly distributed so careful consideration must be taken in future analysis to check for the distribution of the critical thinking grades.

H10: Increased measures of actual use will moderate the effect by positively strengthening the relationships between perceived learning and actual learning (critical thinking).

Finally, I also found a significant moderating effect of Actual Use (AU) in strengthening the relationship between Perceived Learning and Actual Learning that was measured through a critical thinking question. However, as students used the system more, it seemed that it negatively affected the students' critical thinking question grades ($\beta = -0.16$). Nevertheless, it should also be noted that on average, students who had more assignments were part of Professor Bravo's class which also were the ones who tended to have lower course and critical thinking grades. Therefore, this affected the relationship direction in the model. I thus reviewed this in the main dissertation study.

6.3.3 Main Research Question #3

For Main Research Question #3, I asked: "Are there any significant differences in the effect in enjoyment, learning and critical thinking between students who experienced the PL approach and those who did not?" To answer this, I explored the following main sub-questions.

Sub-question #3.1: Are there any significant differences in perceived enjoyment between students who experienced and those who did not experience the PL approach?

About motivation, for the control condition students indicated that they were slightly more motivated than the treatment section. 80% of the students in the control section indicated that they were motivated to do their best work, whereas in the treatment condition only 73.7% of the students indicated the same. Nevertheless, this difference was not significant (Chi-square = 6.53, $P = 0.16$) at 0.05 significance level.

Similar results were indicated when 76.2% students in the control condition (Mean = 4.03, SD = 1.02) indicated that they were more motivated in the course when compared to 65.8% students in the treatment condition who agreed as well (Mean = 3.72, 1.17). However, the difference was also not significant (Chi-square = 6.61, P = 0.16). (See Table B.31.)

On the question: “Overall, I enjoyed this course”, students in the control condition had higher measures of enjoyment than the treatment condition. This difference was significant (Chi-square = 15.51, P = 0.004) at the 0.05 significance level. 76.3% of the students in the control condition (Mean = 4.21, SD=1.04) agreed that they enjoyed the course whereas only 67.5% did in the treatment condition (Mean = 3.83, SD = 1.22). (See Table B.32.)

Overall, based on the data collected, the students in the in the control section were more slightly more motivated and enjoyed the course more than the treatment section. Nevertheless, not all the questions yielded a significant difference.

Sub-question #3.2: Are there any significant differences in perceived learning between students who experienced and those who did not experience the PL approach?

On the question: “Overall, I learned a lot in this course”, students in the control section felt that they learned more than the students in the treatment condition. This difference was significant (Chi-square = 17.69, P = 0.001) at the 0.05 significance level. In fact, 88.7% of the students in the control condition (Mean = 4.50, SD = 0.80) felt that they learned a lot in this course, whereas only 78.6% did in the treatment group (Mean = 3.83, SD = 1.22).

We used the Cognitive Affective Psychomotor (CAP) perceived learning scale by Rovai. Using the Perceived Cognitive Learning sub-scale, the control condition (Mean = 12.26, SD = 2.641) showed greater measures of perceived cognitive learning than the treatment condition (Mean =11.81, SD = 3.03). However, the independent samples T-test showed that there was not a significant difference (t = -1.693, df = 472, sig-2tailed = 0.101) at the 0.05 level of significance. (See Tables B.38 and B.39.)

Using Rovai's Perceived Affective Learning sub-scale, students in the control condition (Mean = 13.20, SD = 3.68) showed greater perceived learning than the treatment condition (Mean = 12.13, SD = 3.88). The independent sample T-test showed that there was a significant difference (t = -2.99, df = 472, sig-2tailed = 0.003) at the 0.05 level of significance. (See Tables B.38 and B.39.)

Sub-question #3.3: Do students who participate in the PL approach improve their critical thinking skills when compared to those who do not participate?

To assess critical thinking, I utilized a critical thinking question developed with the instructors and given to students in both control and treatment sections. The critical thinking question was based on the IDEALS critical thinking process framework and included specific questions that asked students to explain the steps taken when arriving to a solution. For the first part of the analysis, we use all available data from participating courses. The results for their critical thinking are as follows: Control (Mean – 60.60, SD = 40.90) and Treatment (Mean = 80.24, SD = 31.22). The independent sample T-test showed that there was a significant difference (t = -5.096, df = 345.96, sig-2tailed = 0.000) at the 0.05 level of significance. (See Tables B.38 and B.39.)

However, upon further examination I noticed that Professor Bravo's course grades were lower than in other participating courses. Upon removal of the Professor Bravo dataset, I found that the critical grade average for control (Mean = 80.24, 31.22) and treatment (Mean = 78.52, SD = 33.28) were now fairly close. In addition, there no longer appeared to be a significant difference between the condition and treatment (t = -0.453, df = 288, sig-2tailed = 0.651) at the 0.05 significance level. (See Tables B.40 and B.41.)

6.4 PL Pilot (Preliminary) Qualitative Research Exploration of PL Approach and Website}

In this sub-section, I will explain additional information collected through interviews of instructors and students. These findings were used primarily to discuss how the PL approach was doing in the classroom and to provide us with an idea on how students reacted to the PL approach and the website. We held debriefing sessions with instructors and interviews with students throughout the pilot study duration. Debriefing sessions with instructors lasted about an hour and a half and interviews with students on average lasted about 45 minutes. The interview sessions were transcribed and uploaded to MAXQDA 11. My analysis used a ground up approach in which I let patterns emerge from the data. The patterns are described below and use quotes to substantiate the findings. The findings aim to provide both positive and negative findings found during the interview. The qualitative data has helped me further determine issues with the PL system and concerns that instructors and students had with the PL approach. Results from this pilot in combination with results from the main study interviews will help me guide design suggestions for future development work but also provide additional context for issues that arose during the pilot study.

6.4.1 Instructors' Qualitative Results

Throughout the pilot study, I held debriefing sessions with Professor Alpha, Bravo and Charlie. The debriefing sessions with the instructors helped me work out any issues found during the semester that might have impacted the students currently participating in the PL assignments. Overall, instructors expressed their continued support for the current pilot study and expressed their beliefs that it helped positively with the students. However, they also expressed some issues with the system itself and how some bugs in the system affected the students in different ways. From the discussions we can summarize the following.

Student benefits in the classroom: Instructors expressed overall support and positive reactions from students on the use of PL in their courses including both face to face and online classes. An instructor described that the new PL methodology allowed students to integrate and synthetize the knowledge learned during regular classes into a problem and subsequent solutions that closely relate to the problem-solving process a student would engage in when applying the knowledge learned in class to the real world. In fact, an instructor recalled how a student used what he learned through the PL assignment and applied it into a real-world problem. This real-world application was keeping an inventory system using Excel spreadsheets for their business. To provide more context, the instructor referred to the steps that the students need to engage in when creating a spreadsheet in which the student followed a set of instructions on specific information that the spreadsheet needed to hold from another student and then created a spreadsheet inventory system by determining the information that must be captured, and how all that information must be structured in specific categories.

Another instructor could not recall explicit positive comments but believed that the use of PL in the class was positive and mentioned that by having students come up with their ethical problems, it created a diverse pool of creative problems that other students had to tackle and that gave more diversity to the types of discussion in which students engaged. However, he also mentioned that it was as important and beneficial to the students that they not only needed to justify their own responses with arguments but also obtained a different point of view from reading other students' work on the same ethical problem.

Another instructor mentioned that students benefited in three aspects: 1) First students benefit from getting more students testing their work and thus more individuals are used to evaluate their work, 2) students get more guidelines from having others write additional instructions for them to review and 3) it allows students to take a look at others' work and thus get a different view on how to solve a programming problem in the case of very good student. In the case of a student with weaker background in programming, it gives the opportunity to catch up by learning from other people's work.

High customization and streamlining of the logistics needed to setup assignments: Another set of positive comments by instructors focused on the fact that the PL system was able to streamline much of the work required to set up the assignments tailored to the instructors' specific classroom needs. When presenting the PL assignments, we often show the many stages of the PL method as a standard workflow that includes problem creation, problem solving, grading, and when needed, grade reconciliation through a series of sequential steps done by students (either through peer or self-assessments). In reality, the system we have created is very flexible to account for changes the instructor needs to do. For example, in a computer science classroom we tried to use only certain parts of a regular

PL approach. This was due to the fact that the instructor wanted everyone to begin with the same programming problem and students work according to his instructions. As the instructor mentioned when asked about students creating the assignment: “I think it would be very challenging to do that, because if you ask students to create a question or come up with a plan to test a program, you must provide a goal to solve such a problem… but it’s difficult to come up with instructions. “Therefore, this shows how the system can help instructors define their own workflows by plugging in tasks that can in turn trigger other tasks when needed. For example, a problem creation stage not only could have a corresponding solving stage but before that the creation of the problem can be graded. In fact, when a student grades someone else’s work, the student’s grading activity itself can be graded by someone else, thus having the grader be graded by someone. This can have practical implications for different classes where students grading activity could have some weight into the assignment final grade.

Website and future improvements: Overall, the website was well received by the instructors as it included several quality improvements and enhancements that we worked on throughout the system development lifecycle (SDLC). As we continue developing the website through iterations, the system receives major upgrades before the semester starts and minor fixes are rolled out throughout the semester as glitches in the system pop up.

Instructors who have worked with us for two semesters or more benefit from fixes to the system that they bring up at the end of semester debriefing session. For example, instructors that used the system during Spring 2019 benefitted from a set of improvements based on feedback from the previous semester.

An instructor who had used the system for three semesters mentioned the following: "I feel things were pretty smooth this semester that make things very nice … things that frustrated me last semester." In addition, he offered more feedback on how to further improve the system: "One thought I had, this was not a problem, when I look at the big page with all tasks, I can sort students by their email address, but there is no indication of the students' name on that page. And so sometimes it's easy to tell which student is associated with which email but sometimes is not clear. I know the names are on the system but maybe we can show the name as well as the address."

On the other hand, an instructor who used the site for the very first time had the following comment about the website: "I think it is good, [like] the grade page, because that page gives me an overview or different information organized. I would like to see more information from the page. When students submit work, time stamps, that would be very helpful."

Overall, there were other issues and improvements brought by instructors that we continue to work on, such as the ability to automatically allocate students who have been late to submit their work in an effort to keep the flow of work going and avoiding bottlenecks caused by tardiness. Other issues and future improvements include streamlining the dissemination of the information about PL on the site and making the current information available more visible. Some instructors discussed the need for additional documents and tutorials on how the tasks work.

Viewing others' work and copying assignments: There were also some issues brought by the instructors that caused negative effects on the students. In particular, there was an issue with students copying other students' work despite restrictions placed in the system such as not allowing students to view others' work before submitting their own. This was an issue that we were not able to recreate during testing and while the system has safeguards in place to minimize collusion by anonymizing all tasks in addition to access permissions, there is always the chance for students circumventing the system altogether and sharing knowledge outside the PL website. While we will aim to minimize possible student collusion and sharing of work, fixing issues like plagiarism would be an important future addition to the website but would fall outside this dissertation scope.

System issues and glitches: There were several additional glitches that were brought up during the debriefing sessions and that were compiled on a to-do list that the development team continues to work on. A constant issue that instructors have brought to our attention and that we are currently working on is intermittent outages of the site. We are working together with the NJIT helpdesk to further sort out the problem and get additional storage space on our current database to meet demand caused by the increased use of PL assignments.

Another set of issues brought by several instructors was glitches in messages sent by the system to students in which they were notified of tardiness or missing tasks. This has been a constant issue that we are working on that occurs after students are reassigned to cover for someone who has not completed their work and then the lateness notifications carry over to the new student.

A particular issue brought by another instructor was the fact that some of the accordion tabs for multi-categorical grading that included text boxes for grade justification were not appearing on screen until the accordion was reset by clicking on the accordion tab twice. This caused several students to not be able to submit their assignment and be confused for a couple of days while we worked on a fix. Eventually the glitch appeared only to certain students due to browser issues which was a minor setback. In addition, another browser compatibility issue brought by another instructor was the fact that files downloaded could not be opened normally.

6.4.2 Students' Qualitative Results

I conducted student interviews throughout the pilot duration with 13 students from Professor Alpha and Professor Bravo's classes. In Table B.42, I present anonymized demographic information about the interviewees. As expressed earlier in the sub-section, I used a ground-up approach to let patterns emerge from the data collected. These patterns are reported below.

Students overall expressed a wide arrange of reactions to the PL assignments. However, overall seemed to welcome its addition to their course.

> *"I think it was a positive one. We were able to face realistic ethical problems rather than looking at ones in the past where we know mistakes were made. When you create your own you have to think about it … you pretty much get a firsthand experience rather than reading about something that happened before… and you are forced to think about it." (3)*

> *"I thought they were good, I thought they helped get the point across and engaged me with the material. It felt good instead of reading the scenarios kind of design one and understand the rules. In order to pick a scenario, you had to pick a rule, and in order to write a scenario not so obvious you have to understand the rules. And understand what the rules were about … make the scenarios more interesting …It was positive. "(*4)

> *"I think it was successful. My assignments were graded in a timely manner. I knew what I had to do in a timely manner..."* (6)

> *"I actually liked the experience … you had two students grade it together. If there was less than 10% difference you knew the grade was correct. If there was a bigger gap you could dispute the grade. I think it was good, you know if it's a big difference… The class itself is graded on a curve, the top 25% gets an A, and then goes beyond that ... Some students may be*

incentivized to give students a lower grade. (Thus) I think the dispute grade is a good feature." (7)

"I was indifferent, but I didn't see the harm in it. I would say it was … hmm … yeah I would say I would say indifferent, neutral, I just saw it as another homework assignment to do…. Saw it as another task to do, that's why I was indifferent about it. Until he mentioned extra credit then I was all for it…I did like the opportunity to see other students' code and how they would go through a particular assignment the professor gave us. I thought that was helpful and makes your code better." (10)

"The experience was actually very clear. Compared to the regular approach where the professor grades it. You can see the process of grading; you can dispute your grade … I like that the system is clear… I would choose PL system, this system is really a good approach to test the assignments. I would definitively recommend my friend to recommend the PL system. I would really like my future class to use this system." (11)

"At first I was a little iffy about it and when I got used to do it I kind of liked it more. I felt like it was a lot of help for me to progress as a programmer. Hopefully they use the system to other programming besides [CS] 288 like [CS] 280 and above because they are programming classes… Hopefully they have it for other programming class." (9)

Below I present the quotes from students who did not like the PL experience due to its complexity and perceived unfairness when grading. In addition, some people found that the PL assignment integration should have been explained better in the syllabus to avoid any surprises. For some students, the PL assignments were overwhelming.

"I would probably give it a 3 out of 10. I really didn't like it … First, it was really out of nowhere, it was not on the syllabus. So we had to learn how to do that. It was hard to balance grading other people's homework. It was too stressful, even after the assignment was over our actual job was not over. People were grading the assignment wrong. Even though I disputed it I didn't get that much. I actually got lower that I was supposed to… Made me so that I had to do extra work not specified in the syllabus. Grading was not fair. More anxiety and stress grading other peoples' problems. Created a lot of hate because everyone was asking who gave me that score... everyone was trying to figure out who gave them the score. It was graded by another student and then … revenge." (5)

"I disliked it because it takes forever to get my final grade. It took a month to get my final grade. I feel that one student graded my work incorrectly so

I had to go through and made some comments for the TA to look over. The other reason why I don't like it is two students grading per person seems kind of unfair. .... Happened to me once… the students did not know to grade properly or care enough … If the TA didn't grade I would not know my grade." (8)

6.4.2.1 Aspects Students Liked About PL Methodology.

Detailed Instructions: Students liked the way assignments were structured and their increased clarity. The PL assignments were structured in advance and reviewed by the instructor in charge and researchers to ensure that the instructions are clear to the students. A student wrote:

> *"The most, … the thing that made me happy was the way the professor gave instructions step by step to solve the problem … if the test case does pass give 10 points, if it doesn't pass give 0 points."* (13)

However, there were also some students who didn't get enough instructions and thus felt like they were left to figure out stuff on their own.

> *"I didn't like not having … a clear set of instructions. I think we were just kind of thrown in and signed into the website over there. If I missed something on Moodle like a tutorial that is on me but I don't remember there being one."* (3)

Efficiency of the system when grading: When it came to grading there were some mixed results. For example, a group of students believed that the way the grading was done was efficient due to them being able to instantly see their grade after a couple of days. In another section, we explain that for others the experience was not as smooth. One of the students interviewed explains as follow:

> *"It was a very efficient way of grading. I was able to see my grade more quickly than I would be able to do. Within 2 or 3 days I would know how I did in the assignment."* (12)

Enhanced their assignment experience: Some students believed that the system allowed them to get more from the assignment in a way that they could not with traditional assignments. Students expressed satisfaction from the ability to go over the assignments and thus being able to not only revise it as needed but also the tasks in the assignments were interrelated and had students look at the entire assignment as a whole. Other students believed the assignment improved the way they learned the material where it promoted engaging in the assignment more than simply memorizing material needed to solve the problems.

> *"I thought it was a good way to learn, create your own questions. It made you think about what you learned yourself …You teach yourself so it was the best way to learn.*" (2)

> *"The thing I liked the most was creating the scenario. Like I said, I guess it's one thing to read something, or maybe even write something. I guess it felt better and made me appreciate the material more when I had to understand it and apply it to create something. It's a different amount of effort and learning. Instead of regurgitating the material, use it, transform it and apply to create a dilemma."* (4)

> *"… The approach itself, it's a good idea. You get more from the assignment. Let's assume that you were actually [done].. you still have to go over it a few times. With the help of the system, you take more from the assignment. You don't submit and forget about, you go over it sometimes and memorize some things. You find out some new stuff … You can make the most of the assignment. It's not submit and forget."* (11)

Ability to see other people's work: A group of students expressed their support for the ability to see other people's work and thus learn by example. In a programming class, students expressed the benefit of being allowed to see other people's code and thus gain a different point of view. This allowed students to see different implementation and thus see how they could have written the program differently.

> *"I liked it mostly because I looked at other people's answers. There are multiple ways to come to a solution, there are not set ways. There are*

> *multiple ways to come to a solution and it's interesting to see the ways other students have come up with to solve the problem."* (6)

> *"Mainly just the fact that you were able to grade other people's assignments and use your assignments to see what you could do different. I got 100 and looked at someone else and got 100 as well. That way I could see which one was better … It helps a lot, we did the same thing in a different class, CS 280, he gave 3 solutions … this gave me the same feeling where I could see mine, someone else and someone else who get a 70 or 80 and compare."* (7)

> *"I liked seeing other people's code, some people had really good code ... I liked learning from other people's code … I can refer to my own code, see it run faster or better, look at it and decide."* (8)

Fairness of the grades received: Grades were a great point of discussion by almost all students and there were very positive and also very negative issues that were raised. There were some students who liked the fact that grading was anonymous, thus students could not tell who was grading them and who they were grading as well. This provided students with an enhanced sense of impartiality and thus positively contributed to the perceived fairness of the grades. In addition, other students praised the fact that they could dispute their own grade if they did not like the one they received. For example, a student who was incorrectly graded could send his work to be revised by someone else and even grade it himself and provide arguments supporting it.

> *"I have no issues with other people looking at my code or looking at other people's code. I feel that the grading was fair. The grading instructions were clear." (6)*

> *"I think everything was positive … One thing, in one of the assignments. one of them had an 80 and the other had no grade at all. I know that if one graders did not give a grade there are additional graders but I am not sure…. (Interviewer: Was the grading fair?) Yeah, it has the rubric because you can check what grade others gave you and if it follows the rubric."* (7)

Anonymity of the assignments: Students expressed positively about the fact that assignments were anonymous and thus made it so discussions regarding a specific work were about the substance of the work itself rather than personal attacks against someone. Thus, it allowed them to express freely and critique each other's work. At the same time, students believed that by making it anonymous it reduced the competitiveness of judging each other as well.

> *"I liked the fact that it was anonymous. You are allowed to make the scenario easy or difficult. It did not feel competitive. Every time they were critiquing since they didn't know who you were. It felt … it was good … it wasn't competitive. People were just reading and being critical only if they found the mistake. Made you comfortable in making the scenario as easy or personal or impersonal as you wanted." (4)*

6.4.2.2 Aspects Students Disliked about PL Methodology.

Grades were late depending on the tasks and assignments: Some students complained that the assignments' multi-step process sometimes caused delay on their grades. This is an ongoing issue that affects course sections differently depending on the degree of student participation which vary from section to section.

> *"And one more thing, after the two students grade the assignment, there is no due date after that, my second assignment was graded 2 months ago and was just completed last week. So it probably took a month and a half to do it. When you don't dispute it is very quick but when you dispute, it takes very long." (13)*

Students copying others' work: Another issue brought by students was that students could copy other students' work despite the different permissions and rules set within the PL system. For example, a setting we have is that only students who submit their work can see others work after they submit their own work. However, by default, students can see each other's work while at the same stage in the assignment which is an important aspect of learning by example. When the problems are different this is usually not an issue as every answer is different as well. Nevertheless, in some assignments in which the problem assigned was the same for the entire class, some students were able to view other students' work and submit some of their assignments as theirs despite the permissions set in the system. This was caught by some instructors and thus students were penalized for it. One student shared that a method students used to circumvent some of the rules in place was to ask someone else for their work and thus circumvent the system altogether and then submit others' work as their own.

> *"Actually one of my mates in the class, he submitted the assignment, I think the person who was going to grade the assignment actually copied the assignment. I think (the) professor ... actually gave zero credit to those students who did not do their own work." (13)*

Inconsistency on how assignments were scheduled: There were some issues students expressed related to how the assignments were scheduled. This was related to the fact that as a sequential process, while the assignments had a specific starting date and checkpoints along the way, it was still difficult to ensure that every student got their tasks around the same time due to differences in how students submitted the prior tasks. For example, there were times where students got assigned tasks from different assignments around the same time due to extreme delays on some of the initial tasks from assignments earlier in the semester. Other students mentioned that that they had to rush their work and were locked out of submitting their assignments despite the fact that apparently they had more time.

> *"For the most recent programming assignment. Someone had posted their solution to grade and I had not posted mine. I need to rush mine and I could not catch it. It said it expired. I did not submit mine sooner even though the due date was on Sunday ... I have to race other students if I don't submit it before that." (5)*

Issues with unfair grades given by their peers: A group of students expressed their concerns with how they were being graded by their peers unfairly and thus their grades suffering as a result. Some students mentioned that there were instances when the graders did not put enough effort in to their grades and thus they got less than they deserved. In other instances, the students stated that some students lacked the knowledge to grade and thus this lack of knowledge caused incorrect grades to be posted. Finally, another group of students mentioned that a group of students was able to bypass the anonymity of the system by explicitly or subtly adding certain identifiers to the work submitted. This in turn caused students who were able to grade their friends to give them higher marks than deserved.

> *"I got code that included their name in the code. That person knew who that person was, that was kind of unfair … some people added their name and then tried to give them a higher score." (5)*

> *"I don't want student decisions to affect my grade … sure you can dispute but it will take some time … Guys that got a high grade will not dispute their grades." (8)*

6.4.2.3 Aspects Students liked about the Website.

Website User Experience: Overall, students expressed neutral to positive reviews about their experiences when using the website. Some students mentioned that the website had a clear approach and that the way the dashboard was organized allowed them to see what they had to do. Others mentioned that the website was easy to navigate and had a clear layout. However, there were also some students who had issues with the user experience and deemed it too difficult to navigate. Several students mentioned:

> *"(Liked) the fact that it laid out the tasks, once you get in all the tasks are there, you don't have to maneuver. Everything else was there. Was easy to use." (1)*

> *"I think I liked that It was simple. There was not too much to worry about. It was pretty clear when an assignment was coming up. But I would have liked more instructions on what to do … a lot of the website you will have to navigate on your own. The instructions were pretty much the same. It mentions that make sure you save your writing in case something goes wrong with the website." (3)*

“I thought the website was simplistic. Things didn’t feel cluttered. For the most part I was looking at the table and when task would appear … The layout was good, simple, easy to follow.” (4)

“I liked the fact that when you signed in they actually gave you the list of assignments that need to be done. For instance, I actually clicked on the grading part. I clicked on grading and then it took me back, it said you can’t do it and have to complete it first - that was good. The fact that it [the assignment table] was color coded … when a task was optional … key terms … complete, optional, stuff like that.” (9)

“The dashboard, I was able to see the pending tasks on what I had to do, easy access for what I had to do. I liked the side menu, I thought it was pretty cool, clean UI and not too intrusive. For the home was pretty self-explanatory ... It was a clean design.” (10)

“So about the website, I would say as I really liked the interface and user experience approach, as well how the grading task was presented …The table, the state of things when you grade, when you dispute … this table, the chain of actions for each assignment. It was easy to go through all the tasks and navigate … It was a good representation of the grading assignments. It was a good website compared to some universities, that are not as user friendly as I would find the PL website.” (11)

Ability to provide justifications while grading: Some students liked the ability the website gave them to justify the grades they gave to others and thus further explain their reasoning.

“The website was easy to navigate through. I liked how you are given the opportunity to explain how you gave someone a specific grade.” (6)

Notifications and Alerts: Several students expressed positively about the notifications system and how it helped them keep up with the tasks assigned to them. The notifications allowed them to visit the website when work needed to be done and thus reminded them when they needed to visit the site.

“I liked the notifications, that was nice. I liked that you got emails when the assignments were due.” (2)

6.4.2.4 Aspects Students Disliked About the Website.

Issues with grades: Finding and viewing their grades were important issues raised by students that were not only affected due to student's lateness but also due to certain aspects of the website that were not clear to them. For some students, for example, it was extremely difficult to determine what their grades were which was compounded by the fact that even if they knew what grade they got on one task, it was hard to reconcile their final grade after going through the initial set of graders and anyone else that followed as part of disputing the grades. Students mentioned:

> *"One thing I didn't like. After I got my assignment graded by someone else… After they gave me their grade. There was no way to find out my grade. I wish I could get (final) grade, was not clear to me." (6)*
> *"Now I remember, was not easily able to determine what is my final grade. I was talking about a grader report …. I found it a little bit slow as I would like it to be. It was irritating to go through so that is why I would like some kind of summarization …" (11)*

Issues with notifications from PL: Several students expressed concerns for notifications they got from the website. Some students got late notifications without being actually late for their tasks as a consequence of glitches with the systems or the rearrangement of the task assignments as some students were removed from the pool of active students and thus removed from current workflows as they dropped out of the class or simply did not do their work and thus their tasks were given to someone else. In addition, some students got notifications to do some tasks on the website but when they looked into them the tasks could not be found. This behavior could also be a consequence of students taking too long to do their tasks and thus them being reassigned to someone who was active.

> *"I got a notification through email, when I went to check I didn't have anything. Just one time it happened… "(10)*

System downtime: There were some students who raised concerns with issues with the PL system in general. While we monitor the servers regularly to ensure that the systems are up and running, there are times when the system crashes and the system is unable to restart itself. When the system crashes and there are assignments currently running, this becomes an issue that as expected causes issues with students submitting right before a deadline.

> *"I think there was one situation when the system was not working. It was on a Sunday so the students who submitted their work had to resubmit it again. And then he extended the time to redo their work. I think that it was the only time that it happened to the system on the semester." (9)*

6.5 Summary

In this chapter I described the pilot (preliminary) study I conducted in preparation to the main dissertation study. Key takeaways from the main dissertation study will be explained in the next chapter. Findings in the pilot study were exploratory in nature as the main goal was to test the instruments and the website as well. In this chapter, the majority of the research questions were answered except those who referred to the microlearning treatment which was not included in the pilot. Finally, through interviews with instructors and students I was able to determine issues with PL website which will be combined with the qualitative findings in the main dissertation study to provide more insights to the research questions but also guide the PL website design suggestions for future development.

CHAPTER 7

MAIN PARTICIPATORY LEARNING STUDY

The purpose of this chapter is to describe the methodology and results of the main PL study. It should be noted that the main purpose of the study is to 1) re-evaluate the exploratory findings and further verify them and 2) build upon these findings and draw additional conclusions from the data collected. Therefore, rather than reporting all the findings based on isolated data points, the focus will be on finding patterns within the data by cross-tabulating the main constructs with the type of courses and GPA data. In this chapter, I will begin by introducing the main study and limitations, describe the data collected and methodology, and then discuss the main research questions.

7.1 Main Study Introduction

This main study involves 31 sections where 17 were treatment, 12 were control and 2 were microlearning sections. In total, there were 506 students in total (210 control, 271 treatment, 25 microlearning) participated in the main study. (See Table 7.1.) Similar to the PL pilot study, this study involved STEM courses (programming, math) and non-STEM courses (humanities, philosophy) which will be classified as HUM courses. The goal of this main study is to confirm the results found in the preliminary study and build upon it by further dicing the data collected to discover new patterns and relations. Instructor will be referred by the following acronyms: PT, PD, PH, PS, PC, PI, and PE. This will be done to provide added anonymity to the instructors and their courses.

Table 7.1 Main Study Course and Sections

								N
F 20	Course	STEM 1	Professor	PT	Treatment	Section	A	17
							B	16
							C	18
							D	11
							E	10
		HUM 1	Professor	PD	Control	Section	F	9
							G	7
							H	14
					Treatment	Section	I	11
		HUM 2	Professor	PH	Control	Section	J	11
					Treatment	Section	K	6
							L	8
		STEM 2	Professor	PS	Control	Section	M	12
					Treatment	Section	N	14
					Micro Treatment	Section	O	12
							P	13
		HUM 3	Professor	PC	Treatment	Section	Q	19
							R	18
S 21	Course	STEM 3	Professor	PI	Control	Section	S	32
							T	25
					Treatment	Section	U	29
		STEM 4	Professor	PE	Control	Section	V	30
							W	29
					Treatment	Section	X	32
		HUM 2	Professor	PH	Treatment	Section	Y	21
		HUM 4	Professor	PD	Control	Section	Z	17
							AA	11
					Treatment	Section	AB	12
							AC	14
		STEM 2	Professor	PS	Control	Section	AD	13
					Treatment	Section	AE	15

7.1.1 Main Study Limitations and Issues

The focus of the main study was to a) re-evaluate the findings in the pilot study and b) build upon the previous findings by further decomposing the data to find meaningful relationships between the main variables of interest (perceived learning, perceived enjoyment, and recommendation for use) by specific groupings including the type of courses and GPA data.

In addition, there are several confounding factors and limitations that must be acknowledged and that have framed the analysis and results. The most important limitation of the study is that this was conducted with the COVID pandemic in progress and as such there were factors that could not be accounted for. First, I will list factors related to the pandemic and then discuss other confounding effects.

1. Pandemic factors: The mode of instruction switched from face-to-face to strictly online classes. Whereas the unintended effect caused all the sections to be uniform in the mode of instruction, there were some issues that arose from the abrupt change.

    - Moving from face-to-face to online caused students who were not adept at using technology to have to learn throughout the semester. This learning process was confounded by having to also learn to use the PL system. Without the ability to help someone face-to-face, it added difficulty to the troubleshooting process and help that many students required. Whereas WebEx screen sharing aided on the task, helping students still remained a challenge.

    - Moving to fully online had the potential to increase the number of distractions that students could encounter as they were not physically in the classroom and thus may not have been able to fully immerse in the class activities which also included PL assignments.

    - Due to the unknown and rapidly developing health emergency, there were instances where students would suddenly drop or become unavailable which would cause disruption in the PL approach.

- Due to the change in class dynamics, many instructors decided to wait an additional semester before incorporating the PL approach due to their own changes to their curricula to account for online instruction.

2. Instructor effect: Differences in classroom dynamics can be attributed to the differences in instructor effectiveness. As an important confounding variable, it should be acknowledged that there is indeed a possibility of this effect being present in the current study. In particular, the instructor effect would be stronger than during the main study than the pilot due to the fact that students' interaction in the course was tied directly to the instructor rather than dispersed throughout the classroom due to the move to online classes. As the instructor became the sole focus of the course, how instructors managed and conducted the course could quite possibly have a greater effect on the students.

3. Incentive effect: Incentive effect would refer to the differences in participation and grades received between classes as the amount of extra credit they received was not uniform across sections. Similar to the pilot studies, students could not be forced to participate in the study by doing the surveys. Incentivizing students to participate and earn extra credit was needed so that we could collect additional data from interviews but also complete the surveys for data collection

    - For example, for the interviews, it was usually difficult to get more than 10 students each semester and through the extra credit incentives we ensure higher participation.

4. The differences in the PL number of assignments and tasks will be partially accounted for by doing additional data slicing and comparing treatment sections against their same equivalent control section whenever available.

7.1.2 Main Study Research Questions

The following are the research questions that were explored in this main study. It should be noted that I will review the findings from the pilot study while aiming to further expand on the main research questions results from the pilot.

1. Main Research Question #1: How does the PL approach affect the students in the course when applied to assignments?

    - Sub-question #1.1: Do students enjoy their learning experience in the Participatory Learning approach for assignments?

    - Sub-question #1.2: Do students perceive learning in the Participatory Learning approach for assignments?

- Sub-question #1.3: Do students perceive learning from each aspect of the PL approach for assignments? (i.e., create problem, provide solution, grade others, viewing others' work)

- Sub-question #1.4: Would students recommend using the PL approach for their assignments?

2. Main Research Question #2: Do the hypotheses in the model used by Wu, Hiltz, and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?

    - Sub-question #1.1: Do all hypotheses in the original model hold true for assignments?

    - Sub-question #1.2: How can I extend the Wu, Hiltz, and Bieber theoretical model to account for actual learning (critical thinking) and system use?

    - Sub-question #2.3: How does microlearning affect the model?

3. Main Research Question #3: Are there any significant differences in the effect in enjoyment, learning and critical thinking between students who experienced the PL approach and those who did not?

    - Sub-question #3.1: Are there any significant differences in perceived enjoyment between students who experienced and those who did not experience the PL approach?

    - Sub-question #3.2: Are there any significant differences in perceived learning between students who experienced and those who did not experience the PL approach?

    - Sub-question #3.3: Do students who participate in the PL approach improve their critical thinking skills when compared to those who do not participate?

7.1.3 Main Study Methodology

In this subsection I will describe the methodology of the main study including the changes in the data collection and other improvements made based on feedback from the pilot study.

7.1.3.1 Data Collection Changes from Pilot. The data collection process for the main study was updated from the pilot study to account for repeated measures of our constructs. The surveys, which include a pre, mid and post-survey for each condition (control, treatment and microlearning) have been added to the Section C.1 through C.9. In addition, I have also added a summarized list of new questions that were added or modified from the original pilot study. This list of changes can be found in Section C.10. Overall, the following are the list of changes in the main study surveys:

1. The end of semester final pilot survey has been split into three surveys
2. For microlearning group, the survey contains 4 additional questions, which are asked twice during the mid and post survey.
3. The survey scale has been changed from 1-5 to 1-7.
4. There have been clarifications to the survey wording that references to “system” which now refer to the PL website
5. In the pre, mid and post surveys, I changed the tense form of the verbs for the majority of the questions to better reflect the intention of the question in relation to when the survey is taking place during the semester.

For the first major update, for this study I collected general demographic questions during the first survey given to all students at the start of the study. Then, I collected the same measures twice by administering the same survey twice during the middle of the study (for the treatment and microlearning sections this would be after the first assignment if there is more than one and for the control would be around the time the other conditions have taken their survey), and then at the end of the semester a week before final exam week. By collecting repeated measures, it gives the ability to determine differences over time for several of the constructs including perceived learning, enjoyment and recommendation, in addition to measures over time about the PL system. The goal is to determine if there are any perceived differences over time. The measures collected in the main study are the same and use the same questions as the survey from the pilot study.

For the third major update, I increased the Likert scale from 5 to 7 in the survey questions that used it. When the data was collected initially, I noticed that the answers seemed to be heavily weighted towards the middle scale (3 out of 5) and thus, there could be a benefit of increased sensitivity from expanding the number of choices students had. According to a study by Finstad, it concluded that a 7-point Likert scale provided a more accurate measure of a participant's evaluation and was more appropriate for electronically distributed and unsupervised questionnaires [94]. The distribution and supervision method in Finstad's study closely resembles how the PL the surveys were taken so it was a good fit for the study as the PL surveys were given through a word document with instructions linked to a Google form posted on the participating course Learning Management System (LMS). While I check for the survey response ratio so that I can remind students to do their surveys, there is little supervision on how the surveys are taken since they are done individually by the student at their own workspace during the pandemic, which was similar to the conditions described by Finstad [94].

7.1.3.2 Methodology Description. In this subsection I will describe the methodology of the main study. Similar to the pilot study, instructors who participated for the first time in the PL study worked directly with me to create PL assignments that were based on the regular assignments that the instructors were already giving to students or based on topics in which they were aiming to give homework. For recruitment, it was important to have instructors who had multiple sections where we could have a control and at least one treatment section. However, due to the limitations and concerns about the COVID pandemic, instructors that were interested in the PL approach were hesitant on adding additional workload by splitting up their sections in treatment and control sections. Similar to the pilot study, instructors agreed to the following:

1. Instructors worked with me to create at least one PL assignment to be given to students.
2. Instructors worked with the me to create a critical thinking question to give to all students at the end of the semester based on Facione's IDEALS critical thinking process framework [87].
3. Instructors agreed to granting extra credit to students who participated in the survey (and in some cases in the interview) studies. In general, extra credit was between 1 to 3 final grade points depending on the number of surveys completed.

However, unlike the pilot study, instructors were asked to provide 20 minutes of class time to introduce the PL approach and specifically the PL system to the students. In addition, additional information was distributed through the classroom's LMS.

Additional information distributed involved an updated PowerPoint presentation with course-specific information related to the course first PL assignment, PL features, and how to navigate the website in order to provide additional support to students. Finally, some instructors allowed me to join the class WebEx session to provide direct technical support to students struggling with the assignments.

Similar to the pilot study, the amount of extra credit varied across courses depending on the instructor. Whereas the Pl assignments were mandatory to the students, due to IRB limitations, participation in the surveys and interview was voluntary. Therefore, even if we had data on the students related to their PL participation, we could not use it if they did not provide consent through the survey.

The control section of the course served as a baseline that was used to compare the effectiveness of the treatments (regular, microlearning). The majority of the sections in the study were completely online with a very few sections being converged. Nevertheless, the vast majority of students in the converged sections took the class online so this was negligible.

To ensure similarity, whenever possible, I converted the regular assignments in the control section to a participatory learning form for the treatment sections. For the control section, similar to the pilot study, there was no change in the teaching dynamics or in how the regular assignments and exams were administered. However, students were surveyed and evaluated to determine their satisfaction with the course (survey), perceived learning (survey) and actual learning through a quiz or exam given at the end of the semester that tests critical thinking aspects.

For the regular and microlearning treatment sections, students had the same class materials given to the control group. In addition, students in the treatment groups were also allowed to use the resources available to the control group in addition to having access to the PL system. For PL assignments in the regular treatment section, students participated throughout the entire assignment process which included a combination of 1) creating a question, 2) developing a solution, and 3) grading peers. (Nevertheless, for the humanities courses, students did not get to come up with a question but did get involved in the revision of other students' work and grade each other.) Additional tasks in the assignment process included self-assessment tasks that allowed students to dispute their grade when needed. For students in the microlearning section, their assignments were similar to the regular treatment section but broken down over multiple tasks that were delivered to them as they completed the previous one. For example, a regular assignment task that lasted seven days would be broken down into two or three tasks and spread out over a seven-day period but with shorter deadlines in between each task.

Table 7.2 provides an overview comparing similarities and differences between the regular, microlearning and control conditions.

Table 7.2 Control, Regular Treatment and Microlearning Treatment

	Control	**Regular Treatment**	**Microlearning Treatment**
Lecture	Normal class recitation and materials		
Assignments	1-3 class assignments throughout the semester	1-3 PL assignments throughout the semester.	1-3 PL assignments with micro-tasks throughout the semester
PL website	None	PL system introduction	
General Survey	Course Satisfaction and Perceived Learning		
PLA System Survey	None	Perceived learning and satisfaction from using the PL system.	
Microlearning Survey	None		Perceived learning and satisfaction from doing smaller tasks.
Critical Question	Critical thinking question created with the help of the instructor.		

7.2 Main Study Data Description

The data collected for this main study has been previously described in Section 5.3 PL Model variables subsection. In this section, I will provide an overall description of the data collected in the main study including the surveys, interviews and grade data. Whereas in the pilot study the goal was to explore the data collected and provide descriptions for them individually, this section will instead describe the structure of the data collected. In Section 7.3, the data results will be framed based on the main study research questions.

7.2.1 Surveys

The main set of data collected for the study was done through surveys approved by NJIT's Institutional Review Board along with the interview protocol. Given the size of the questions set for all three surveys, rather than listing them again in this section, they can instead be found in Appendix C. The questionnaire (survey) used for each condition in the main study used to measure the PL constructs can be found in Section C1 to C3 for the regular treatment, in Section C4 to C6 for microlearning treatment condition and in Section C7 to C9 for the control condition. The consent form for the surveys can be found in Section C11.

The data collected was a mix of numeric and text data. Numeric data was collected through Likert scale questions with a range from 1 (disagree) and (7) agree. In addition, the surveys included standard instruments for Perceived Cognitive and Perceived Affective Learning (CAP Survey) developed by Rovai [84], and also included the System Usability Scale (SUS) developed by Brooke [85] to evaluate the PL website usability. Rovai's scale output range was 18 for the Cognitive and Affective score and the SUS output range was from 0 to 100. The questions that included text responses were related to the user demographics including gender and race, in addition to an open-ended text field for feedback.

7.2.2 Interviews

Interview consent forms can be found in Section C.12 for students and C.13 for instructors. The interview protocol for students can be found in Section C 14 for students and for the instructors in Section C.15. Students were interviewed at the end of the semester and in some courses received extra credit for their participation. The complete list of interviewees in this main study (with demographic information) can be found in Table 7.3.

Table 7.3 Interviewees Demographic Information (Main Study)

#ID	Sex	Age	Race/Ethnicity	Major	Year
DS1	Male	22	Egyptian	Mechanical Engineer	Junior
DS2	Male	20	White	Mechanical Engineer	Sophomore
DS3	Male	19	Cuban-Dominican	Chemical Engineer	Sophomore
DS4	Female	18	Irish	Sports Administration	Freshman (1st Year)
DS5	Female	18	White	Business Administration	Freshman
DS6	Male	21	White-Irish-American	Sports Administration	Junior
DS7	Male	19	White	Sports Management	Freshman (1st Semester)
DS8	Male	19	Black-Hispanic	Business (Undecided)	Freshman
DS9	Female	18	Asian	Marketing	Freshman (1st semester)
DS10	Female	18	Caucasian	Business Administration	Freshman
DS11	Male	18	White	Accounting	Freshman (1st Semester)
DS12	Male	18	White/Native-American	Marketing	Freshman (1st Semester)
DS13	Female	18	Asian	Business Management	Freshman
DS14	Male	18	Caucasian	Accounting	Freshman
DS15	Male	18	African-Black	Business Administration	Freshman (1st Semester)
DS16	Male	21	Canadian	Business Administration	Freshman
DS17	Male	26	White-European	Computer Science	Senior
DS18	Female	20	South Asian/Indian	Computer and Business Major	Junior
DS19	Male	29	Caribbean-Hispanic	Marketing	Sophomore
DS20	Male	20	White-Latino	Marketing/Minor Accounting	Sophomore
DS21	Male	18	African-American	Accounting	Freshman
DS22	Male	19	Caucasian	Marketing	Freshman
DS23	Female	21	Middle Eastern	Business Administration	Junior
DS24	Female	19	Hispanic	Marketing/Minor in Economics	Freshman
DS25	Male	21	Asian	Computer Science/IT Minor	Junior

7.2.3 Course Grade and GPA Data

The course grade was collected from the instructor for each student who consented to participate in the study. The GPA data was provided directly from the appropriate university statistical data office at NJIT and FDU. This data was numeric and ranged from 0 to 100. However, some students did not have a GPA at the start of the semester, so it was left blank.

7.2.4 Critical Thinking Grade

Instructors administered the critical thinking question at the end of the semester to all conditions. The grading was done primarily by the instructor and then the data was reviewed by me. Instructors were given a rubric to facilitate the grading process which was then tailored to fit the question. In the event that an instructor could not provide the grading, the grades were done by a single a single expert grader who graded the entire course to ensure consistency across all sections in the same course. It should be noted that there were sections that did not run a critical thinking question due to how those professors conducted their courses and some courses not having required a final exam. The critical thinking question was mandatory in 15 sections, optional in 10 and not conducted in 5 sections.

7.2.5 PL Data

Data collected from the PL system included the number of assignments completed, number of total assignments, and task grades. To ensure a consistent recording of PL activity, an assignment was deemed completed if the assignment reached the dispute stage in the system. Students who partially completed their assignments quite often held the process and often were taken out of the assignment. Once a student was removed, their tasks were reassigned to other students (either reassigning tasks in a way that ensured that all participating students had an equal number of tasks, or asking for volunteers willing to do extra tasks). Whereas an argument can be made about measuring activity by the number of tasks completed, it should be noted that even in similar assignments, not all tasks would be the same amount of work. In addition, for the microlearning condition, students would have an additional number of tasks while engaging on a similar number of assignments that would total about a similar workload as the regular treatment condition so additional tasks would not necessarily mean greater activity. Finally, in most assignments, late students were taken out early so the number of tasks that they were exposed to were limited.

7.2.6 Data Analysis Methodology Description

The data collected was analyzed using SPSS for descriptive statistics and test of significance. Data was analyzed quantitatively using SmartPLS to test the PL model hypotheses using Partial Least Squares which was the original method used in the study by Wu, Hiltz and Bieber. In Section 7.3.2, additional description on the appropriateness of the PLS analysis is provided. The qualitative data from the interviews was analyzed using a ground-up approach in which I derived findings based on the data presented.

Self-reported measures on students' perception were measured using a 7-item Likert scale. Whereas the mean would work better to describe central tendency in normally distributed data, the median would better describe centrality when the responses are weighted towards both sides of the scale. Therefore, in the findings described in section 7.3, any descriptive statistics report would include mean, median and standard deviation. Chi-square was used for the ordinal variables and t-test for numerical variables.

The Chi-square test requires two assumptions. The first assumption is that the two variables are measured at the ordinal or nominal level and the second assumption is that the data consist of two or more independent groups. These two assumptions are met since the data collected comes from two different independent conditions (regular vs microlearning vs control sections). Because chi-square is a non-parametric test, the assumption of normality was not needed. T-test was also used for variables that included the following: course grade, critical question grade, CAP cognitive score, and CAP affective score. In Tables C.16 though C.21, I include descriptive statistics for the survey variables including mean, median, standard deviation, skewness and kurtosis.

Based on the descriptive output appended, the PL Grade variable had a skewness of -1.424 and kurtosis score of 0.765, so should merit some consideration especially given that the median was 96 while the mean was 80. Therefore, the PL grade data presents slight skewness towards the higher end of the range which could indicate students grading generously as expressed by some students during the interviews. Another data that appears to be skewed is the GPA grade data. In Figure 7.1, it is shown that the majority of grades appear to be on the upper end of the range. In addition, the kurtosis score was -2.024 and the skewness was 3.1.

Since GPA was intended to be used to differentiate high performing students from lower performing students, after recoding the GPA grade into four groups (3.5001 thru 4 for ‘Top/High GPA’, 2.001 thru 3.5 for Medium GPA, 0 thru 2.0 for 'Low GPA' and those with no GPA into 'No/Missing GPA' variable), the bigger grouping was Top/High GPA with 220 students, Medium GPA with 175, Low GPA with 47, and No/Missing GPA with 64.

Therefore, given that a large majority in the dataset are high performing individuals, this gives us more information about the quality of students from which we collected information.

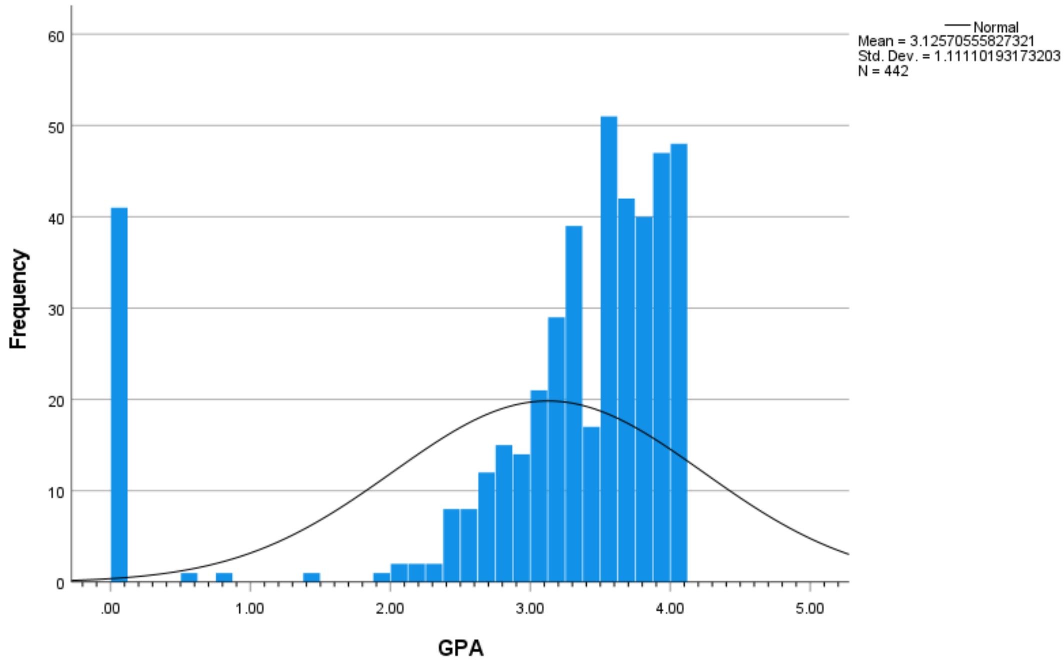


Figure 7.1 GPA frequency distribution.

7.3 PL Main Study Research Questions

For the main study, one of the main goals was to find deeper connections in the data based on perceived learning, perceived enjoyment and recommendation for use and explore these findings to answer in more details RQ#1, RQ#2 and RQ#3. Therefore. I will not only revisit the Main Research Questions #1, #2 and #3 explored initially in the pilot study but also aim to draw additional conclusions.

7.3.1 Main Research Question #1

For Main Research Question #1, I asked: "How does the PL approach affect the students in the course when applied to assignments?" Thus, it was important to evaluate how the PL approach affected students' perceived learning at each stage of the assignment and if they would recommend it. It should be noted that this section explores only the treatment condition it does not include the microlearning exploratory section nor the control section (N:271). Questions related to comparative measures between the treatment and control are answered in RQ#3. In addition, significant tests performed in this section seek to find differences in perceived learning, perceived enjoyment and recommendation against independent variables like course, course type (humanities or STEM), and GPA Level (Missing indicated no GPA, Low: 0 to 2.5 GPA, Medium: 2.5 to 3.5 GPA and High: 3.5 to 4 GPA) so when a significant difference is reported, they are related to differences in degrees in perceived learning, enjoyment and recommendation across the treatment sections. This would allow us to answer, for example, if there is treatment section that did significantly better (or worse) when compared to other treatment sections. To answer RQ#1, I explored the following main sub-questions.

Sub-question #1.1: Do students enjoy their learning experience in the Participatory Learning approach for assignments?

In the pilot (preliminary) study, a key finding was that students in the treatment condition who participated in the PL approach did in fact enjoy multiple aspects of it. In the pilot study, 54.3% of students expressed that they enjoyed the PL approach, which represented the majority of students. In the main study, 48.3% of students enjoyed the PL approach whereas 30.6% did not enjoy the PL approach. (See Table C.22.) In the main study, 59% of the students agreed that they liked the number of tasks assigned in the PL website and 49.1% expressed motivation to work on their PL tasks (assignments) when compared to 27.2% who did not. See Tables C.23 and C.24 respectively. Overall, the results were consistent with the findings in the pilot study.

In Table C.25, I dice the data on enjoyment based on Course and GPA. The results show that students in HUM 3 (70.2%, Mean: 5.30), STEM 1 (54.2%, Mean:4.50), and HUM 2 by PD (53.8%, Mean: 4.58) expressed greater enjoyment with the PL approach. It should be noted that both HUM 3 and STEM 1 had PL assignments that were more involved than regular assignments by requiring students to work throughout the semester on them. Pearson Chi-Test (see Table C.26) and ANOVA test (see Tables C.27 and C.28) were conducted and found statistical significances between courses. The post-hoc Tukey test (see Tables C.29a, and C.29b) tells us that there were significant differences between HUM 3, STEM 3 and STEM 4. Unlike STEM 4 and STEM 3, HUM 3 had a semester long project where students submitted their work (video work) to the PL system to have their peers review it and then had two other peers grade them. On the other hand, STEM 4 and STEM 3 ran regular PL assignments where students came up with questions, solutions and graded each other, so it was more streamlined without much interaction or revision stages.

In addition, after comparing the responses to “I enjoyed the PL approach” by GPA level, I did not find any significant difference between the groups despite all expressing positive interest in the PL approach. (See Tables C.30, C.31, C.32, C.33, and C.34.) It should be noted that the variable “I enjoy the PL approach” that was sliced by Course and GPA met standards of normality. (See Table C.35.)

Finally, an important topic of discussion from interviewing students was that they thought that the PL approach fit well with courses with assignments that were open ended similar to ‘essay type’ coursework. The results confirm the comments that students brought up with relation to enjoyment in the PL approach. When divided by course type (science, humanities) and further diced by GPA level, there were some interesting findings. In general, there was a trend that students in the humanities courses ended up perceiving higher enjoyment in the PL than those in science in general. Students in the highest GPA group in humanities (53.7%, mean: 4.8) expressed greater measures of enjoyment than those in sciences in the same GPA group (47.7%, mean 4.2). (See Table C.36.) In addition, when a 2-way ANOVA test was conducted, the test did find a significant interaction between course type and enjoyment, but did not find an interaction by course type, GPA, and enjoyment. (See Table C.37.) However, although there were no significant differences when slicing the data by course type and GPA, there was a trend across all GPA levels in which humanities courses expressed greater enjoyment as shown in Figure 7.2.

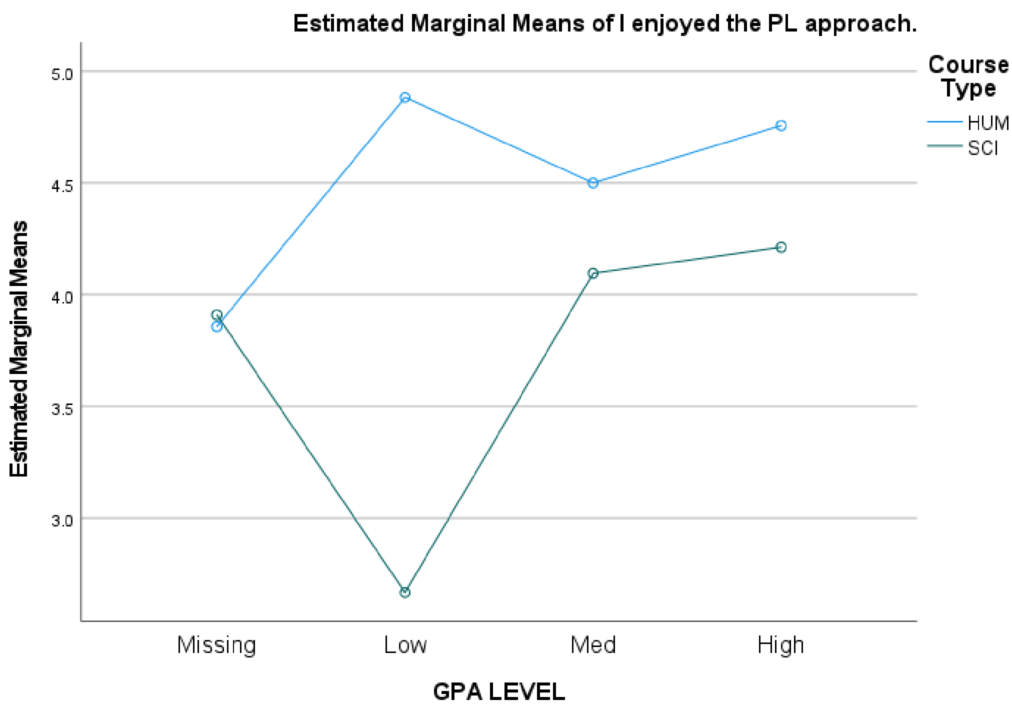


Figure 7.2 Marginal means of enjoyment by GPA and course type.

Overall, regarding RQ1.1**, I can state that most students enjoyed being part of the Participatory Learning approach for assignments. In addition, although all courses reported that the majority of students enjoyed the PL approach, the humanities courses significantly performed better than science in terms of enjoyment.**

Sub-question #1.2: Do students perceive learning in the Participatory Learning approach for assignments?

In the main study, 49.0% of the students believed that the PL approach helped them learn more when compared to 28.1% who did not. (See Table C.38.) This finding is lower than the pilot study where 55.4% of students in the treatment condition perceived that the PL approach helped them learn. Also, it should be noted that Perceived Learning variable met standards of normality with -0.29 Kurtosis and -0.289 Skewness. (See Table C.39)

When grouped by GPA level, the degree of perceived learning remains similar across all groupings. (See Table C.40.) To test for significance, I ran a Chi-Square and ANOVA test for Perceived Learning and GPA level. The tests report no significant differences for both (see Tables C.41 and C.42) and follow on post-hoc tests Tukey and Dunnet did not find any significant relationship. (See Tables C.43 and C.44).

However, when grouped by specific course (see Table C.45), HUM 3, STEM 2 and STEM 1 reported the highest degree of perceived learning from the PL approach. In both HUM 3 and STEM 1, the PL assignment involved a semester long project which was open ended and that was more involved that other PL assignments that did not necessarily include revision stages. In addition, these sections also reported higher measures of enjoyment in the PL approach. In the case of STEM 2, while the assignments were not as work intensive as those in HUM 3 and STEM courses, nevertheless they did involve several revision stages with the Professor. Nevertheless, when a Pearson-Chi square test was run, the differences were not significant. (See Table C.46.) Still, the one-way ANOVA test did find significance at 0.014 for differences between groups. (See Table C.47.) The Tukey test (see Table C.48, C.49a, and C.49b) determined significant differences between HUM 3 and STEM 3, and also significant differences between HUM 3 and STEM 4. Once again, only the philosophy course turned out to be significantly different than the others by having greater measures of perceived learning when compared specifically with STEM 3 and STEM 4.

Finally, when slicing the perceived learning by course type and GPA level (see Table C.50) using a two-way ANOVA, there were no significant differences by GPA nor by course type.

Therefore, regarding RQ1.2**, I can state that most students perceived learning benefits from being part of the Participatory Learning approach for assignments. In addition, while there was a significant difference in increased perceived learning across specific courses within the treatment, there were not significant differences in perceived learning by GPA or by course type.**

Sub-question #1.3: Do students perceive learning from each aspect of the PL approach for assignments (i.e., create problem, provide solution, grade others, viewing others' work)?

Based on the data presented, students in the treatment condition had a positive attitude towards the PL approach and perceived that each aspect helped them learn to a varying degree.

Students seemed to have higher measures of perceived learning from making up problems (68.20%) and seeing others' work (63.10%) than from solving (54.3%) or grading others (55.4%). These results mirror the results from the pilot study which found a similar proportion of people favouring making problems (65%) and viewing others' work (67.5%), and learning from solving (59.1%) and grading others (62%). It should be noted that making problems had the highest percentage of perceived learning based on the four PL perceived learning questions. Given that making up a problem is at the highest level of Bloom's taxonomy, it seems that engaging in these higher-level cognitive activities through the PL approach makes students' learning perception increase. Their experience creating problems seems to be reflected on their increased positive views of the approach when compared to the other parts of the PL process. (See Table C.51). The variables related to perceived learning from making problems, solving, grading and viewing others' work satisfied normality. (See Table C.52.)

During the pilot study, a question that came up was whether students in STEM or humanities would perceive differences in their learning for each aspect of the PL process. The percentage distribution for each aspect can be seen in Tables C.53, C.54, C.55, and C.56. Below I present an analysis on perceived learning for each aspect of the PL process by specific course and GPA, and then a 2-way ANOVA analysis by course type (STEM, humanities) and GPA. It should be noted that for the tests below, I am trying to determine if there were significant differences in the degree of increased perceived learning students experienced given that overall students expressed higher percentage of agreement with respect to learning than disagreement. The tests were therefore conducted to see if there were increased perceived differences in specific courses, course type or GPA levels.

Related to students' perceived learning from making problems (see Table C.57), students in HUM 3 (72.9%) and STEM 1 (77.7%) agreed to have learned from this activity when compared to the lowest scored course HUM 1 (36.4%). To provide additional context, it should be noted that both HUM 3 and STEM 1 worked on a semester long project and engaged in activities where they had to create a problem whereas HUM 1 engaged primarily on draft revisions for essays (where there was no formal create problem stage as students wrote essays before the first PL assignment tasks, which were the draft revision process). This would explain why HUM 1 students specified not perceiving as much learning from this activity. The Chi-square test was not significant (see Table C.58) but the ANOVA test was significant with a value of 0.027. (See Table C.59.) The Tukey post-hoc however could not determine specific significant differences among courses to determine the ones the differed from each other. (See Tables C.60, C.61a, and C.61b.) When grouped by GPA level, the differences were close. (See Table.C.62.) Pearson Chi-square showed significance ($p = 0.039$, df=18) but also warned of possible invalid results due to not having enough observations in some cell counts. (See Table C.63.). ANOVA test showed no perceived increased significant differences across GPA as shown in Tables C.64, C.65 and C.66. Finally, a two-way ANOVA test grouping by GPA and course type showed no perceived increased significant differences as well. (See Table C.67.)

For students' perception related to perceived learning from solving problems (see Table C.68), students in HUM 3 (78.3%) and STEM 1 (63.9%) agreed to have learned from solving problems when compared to the lowest scored course HUM 1 (27.3%). The Chi-square test was significant (p: 0.03, df: 42) but also warned of possible invalid results due to not having enough observations in some cell counts. (See Table C.69.) The ANOVA test was significant with a value of 0.017. (See Table C.70) The Tukey post-hoc test determined significant differences in perceived learning from solving problems between HUM 3 and HUM 2. (See Tables C.71, C.72a and C.72b.) When grouped by GPA level (see Table C.73), the high GPA and low GPA groups reported increased measures of learning over the medium GPA and missing GPA groups. After testing for significance using Pearson Chi-square it showed no significant results. (See Table C.74.) ANOVA test showed no significant differences across GPA grouping for the treatment section. (See Tables C.75, C.76 and C.77.) Finally, a two-way ANOVA test grouping by GPA and course type showed no perceived increased significant differences as well. (See Table C.78.)

For students' perception related to perceived learning from grading others (see Table C.79), students in HUM 3 (72.9%) and HUM 4 (65.4%) agreed to have learned from this activity when compared to the lowest scored course HUM 1 (27.3%). Unlike learning from creating problems and solving problems, HUM 4 engaged on in-class revisions and grading. An interesting finding is that HUM 1 and HUM 4 were taught by the same professor during different semesters. A change that was done was that I came to the online class session several times throughout the semester at request of the professor to oversee the in-class revision and grading process so that students could all do it synchronously. While the same was done in both HUM 1 and HUM 4, during HUM 1 students encountered a lot of difficulties that stemmed from others not submitting their work in time to conduct the synchronous activity. Perhaps, the change in student perception from HUM 1 and HUM 4 can therefore be explained due to additional support for their synchronous online activities which led to HUM 4 having increased learning measures for grading each other work. The Chi-square test was not significant (p: 0.14, df: 42) but the output gave a warning about results due to not enough observations in some cells (see Table C.80). The ANOVA test was significant with a value of 0.001. (See Table C.81.) The Tukey post-hoc however determined specific significant differences between HUM 3 and HUM 1 which were the highest and lowest rated course, and also significant differences between HUM 3 and STEM 2. (See Tables C.82, C.83a, and C.83b.) When grouped by GPA level (see Table C.84), the lowest GPA level reported the highest measures of increased learning from grading each other. However, this group was very small in proportion to the medium and high GPA so that should be considered. Pearson Chi-square showed no significance. (See Table C.85.) ANOVA test showed no significant differences in GPA levels. (See Tables C.86 C.87 and C.88.) Finally, a two-way ANOVA test grouping by GPA and course type showed no perceived increased significant differences. (See Table C.89.)

For students' perception related to perceived learning from viewing others' work sliced by course (see Table C.90), students in HUM 3 (83.7%) and HUM 4 (73.1%) agreed to have learned from this activity when compared to the lowest scored course HUM 1 (36.4%). In HUM 4, students actively engaged in revisions at multiple stages of their assignment by 1) giving each other feedback on early drafts and 2) grading each other (despite the grade not directly affecting the final assignment score). In turn, HUM 3 had weekly presentations where the professor and a designated student expert discussed a topic weekly by creating questions through the PL system and then grading the presentation response and presentation through the PL system. Therefore, there were a lot of opportunities to review others' work and thus it seems students in this class enhanced their learning experience more than the other courses. The Chi-square test was significant (p:

0.005, df:42) but it showed issues with observations per cell so the results are not reliable (see Table C.91). The ANOVA test was also significant with a value of 0.004. (See Table C.92.) The Tukey post-hoc determined significant differences between HUM 3 and STEM 3, and HUM 3 and STEM 4. (See Tables C.93, C.94a, and C.94b.) A comment from a student in STEM 1 noted during an interview that they did learn from reviewing others work as looking at their code it was a good way to learn. This is an interesting comment because whereas the other two classes had significantly lower perceived learning scores from viewing other work, this was not the case for STEM 1. When looking at the assignments, whereas STEM 3 and STEM 4 had assignments that involved mostly design or solving mathematical equations, in STEM 1 the main assignment was a semester long project where students reviewed each other code and ultimately graded it as well. When grouped by GPA level (see Table C.95), it once again appeared that students in the low GPA group had increased learning from viewing others work. Pearson Chi-square showed no significant results. (See Table C.96.) ANOVA test also showed no significant differences across GPA levels. (See Tables C.97, C.98 and C.99.) Finally, a two-way ANOVA test by GPA and course type showed no perceived increased significant differences as well. (See Table C.100.) Despite not being significant differences in perceived learning from viewing others' work across course types, there were indeed significant differences in increased perceived learning across specific courses. Most noticeably, HUM 3 and HUM 4 had students expressing increased learning from viewing others' work when compared to the other classes. The type of PL assignments students engaged in would have played a role as they were designed to expose students to a lot of work by others. Finally, although not significant, students in the low GPA condition seemed to express additional perceived learning measures from viewing others' work which would explain the lower performing students benefitting the most from observing others.

Other trends that did not have significant results were that overall it seemed that students in the STEM courses had higher perceived learning when making problems. This could be explained due to the fact that the humanities course students did not have to make up much of their own problems as their PL assignments were focused on providing feedback to each other. In fact, students in the humanities courses did report greater perceived learning measures when reading other people's work (70.6%) than those in STEM courses (54%). However, it should be noted that the STEM courses did also review others' work and students from the programming courses did report that they enjoyed viewing others' code as it helped them with their own learning by providing a different way of coding a problem.

Therefore, regarding RQ1.3, **I can state that the majority of the students who participated in the PL approach agreed to have learned from each aspect of the PL approach used for their assignments, and that students in the humanities courses enjoyed viewing others' work while students in the science courses enjoyed making problems. When comparing perceived learning by courses, there were significant differences between courses that implemented traditional PL assignments with straightforward problem creation, problem solving and grading against those courses that implemented additional stages for revision or that made the assignment a semester long project in which students had to consistently engage in the PL activities.**

Sub-question #1.4: Would students recommend using the PL approach for their assignments?

In the pilot study, students were asked: "I would recommend in the future that the PL approach be used for the course and its assignments," and 52.9% of students stated that they would recommend it. In the main study, according to Table C.101, only 45% of the responded stated that they would recommend the PL approach be used for their course and assignments. This variable meets standard of normality (Skewness: -0.186, and Kurtosis: -0.931) as shown in Table C.102.

When sliced further, as shown in Table C.103 it should be noted that students in STEM courses ended up being less likely (42%) to recommend the PL approach than students in humanities courses (48%). However, an interesting finding is that among all the courses, students in HUM 3 were 73% in agreement to recommending the course whereas students in other humanities course were also among those less likely to recommend the course to use the PL approach for assignments. In fact, only 27% of students in HUM 1 were among those who agreed to recommend PL for the course. It should be noted that HUM 3 had a more hands on approach with a semester long project. Whereas both courses conducted three PL assignments, the HUM 1 section worked on using the PL approach to formalize the essay feedback process while HUM 3 incorporated the PL assignment as part of their semester long project. To explore if these differences were significant, data was sliced by individual course in Table C.104, in this table we can see that HUM 3 had 72.9% and STEM 2 had 51.7% of students agree to recommending the course use PL approach whereas STEM 4 had 34.4 % which was the lowest agreement for recommendation with a mode of 1. The Chi-square test was significant (p:0.015, df:

42) but the results could be invalid due to not enough observations in some cells. (See Table C.105.) ANOVA test also showed significant differences in recommendation by course at p:0.01. (See Table C.106.) Further post-hoc test reveal that there were indeed significant differences between HUM 3 and STEM 4, between HUM 3 and STEM 3, and between HUM 3 and HUM 2. (See Table C.107, C.108a, and C.108b.) Overall, there were some specific differences between HUM 3 and the other three course. First, HUM 3 had a semester long project which the other courses did not. Second, both STEM 3 and STEM 4 assignments were very straight forward meaning that they utilized the basic PL approach of problem creation, solving and grading for their assignments. In the case of HUM 1, there was a marked lack of participation from students during some of the assignments in this class that were due to a combination of students not doing their work and stopping others from progressing and issues with students getting used to the PL system.

When using GPA for grouping, the low GPA students had 50% of students agreeing to recommend PL for their course (see Table C.109), However, it should be noted that this group is very small when compared to the medium and higher performing students. On the other hand, the other three groupings had measures of recommendation very similar and close to the neutral point. Further analysis of the data show that according to the Chi-square test (see Table C.110), there was no significance differences across GPA groups. The ANOVA test also show no significant differences. (See Tables C.111, C.112, and C.113.) When slicing by course type and GPA using a 2-way ANOVA test (see Table C.114), there were not significant differences by GPA but there were significant differences by course type. Nevertheless, when looking for significant differences by GPA and course type, there were not significant differences. Nevertheless, there was a trend in recommendation by course and GPA according to Figure 7.3. In this figure, we can see that overall humanities courses ended up recommending more at all known GPA levels.

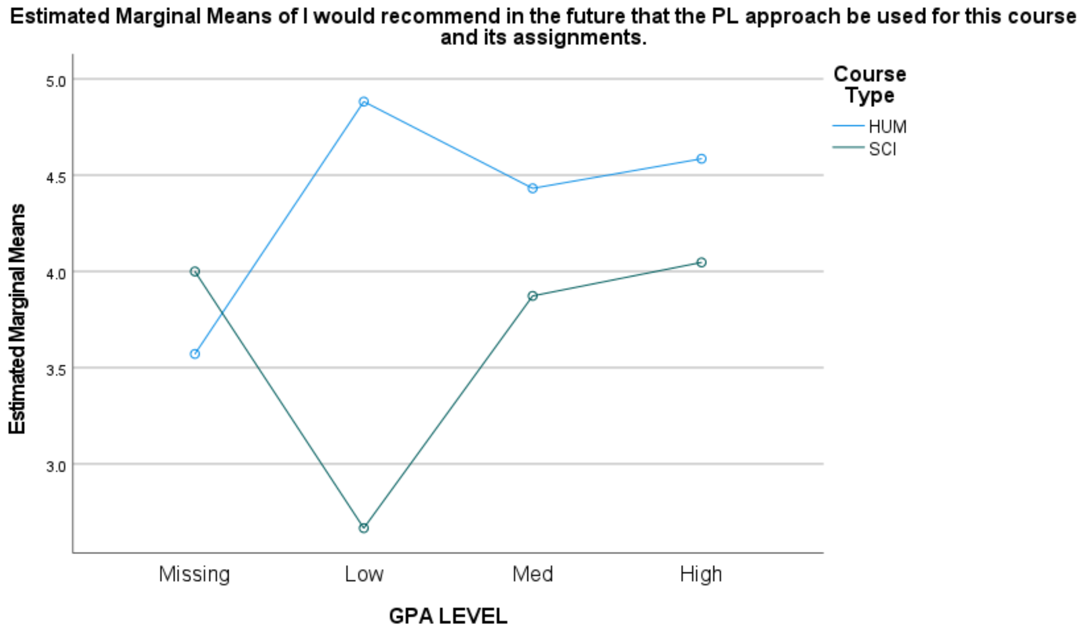


Figure 7.3 Marginal means of recomendation by GPA and course type.

In terms of recommendation of the PL approach, the majority of students did end up recommending the approach for courses. Whereas there were no significant differences in recommendations by GPA, there were significant differences by course and course type. There were some courses that were recommended significantly more than others. In addition, students taking a humanities course would be significantly more likely to recommend the course than someone in a STEM course.

7.3.2 Main Research Question #2

For Main Research Question #2, I asked: "Do the hypotheses in the model used by Wu, Hiltz, and Bieber hold true when applied to assignments and can I further extend the model to account for use and additional learning measures?" Building upon the modified Wu, Hiltz and Bieber model [2] for assignments, I re-evaluated the ten hypotheses of the PL model developed. It should be noted that the following PL model hypotheses do not test the research questions outlined in Chapter 1 but rather test relationships among the constructs in the PL model.

To ensure consistency across the pilot study and the main study, I continued using SmartPLS software to evaluate the PL model hypotheses and used the same settings as the original study. I ran both PLS Path analysis to determine the model path coefficients (strength of the relationships among constructs) and ran PLS Bootstrapping with 1000 iterations, a non-parametric procedure, that allowed me to test for statistical significance of the path coefficients. Regarding missing values, pairwise deletion was used instead of case deletion to maximize the amount of data used in the analysis. PLS analysis does not impose normality requirements on the data [91]. PLS analysis was also used to evaluate the constructs for internal consistency. To answer RQ#2, I explored the following main sub-questions.

Sub-question #2.1: Do all hypotheses in the original model hold true for assignments?

Similar, to the pilot study, I present in Tables C.115 and C.116 the Composite Reliability and Square Root of Average Values Extracted (AVE). Composite Reliability (CR). For the PL model constructs, all CR scores exceeded 0.7 and all AVE's exceed 0.50 based upon the Fornell and Larcker's recommended criteria [92], [93].

Similar to the pilot study, a factor analysis study using the Partial Least Squares (PLS) method on SmartPLS determined the Item Loadings, and Standard Error. The results are presented in Tables C.115, C.116a and 116b. For items loadings, all the constructs items that made up the main construct exceeded the item loading threshold of 0.60. If the construct only had a single item make up the construct, then the item loading will be 1 because it accounts for all its changes. This is the case for Actual Learning, Performance Outcome, Effort Expectancy and Actual Use, all of which had a CR of 1. From Tables C.116a and C.116b), we can see that Facilitating Conditions (CR= 0.89), Perceived Enjoyment (CR=0.88) and Perceived Learning (CR=0.91) had high Consistent Reliability, which tells us that the set of questions and/or measures taken for each construct respectively were closely related as a group. The inter-construct relationships are shown in Table C.117.

The PL model was able to account for a sizable variance in Perceived Learning (R = 0.709), Perceived Enjoyment (R = 0.598), and Recommendation for Use (R = 0.658). However, unlike the pilot study, it did not account for any variance in Performance Outcome and about the same variance in Actual Learning (R = 0.116). Figure 7.4 represents the pilot study results and Figure 7.5 represents the main study results. All significant relationships have been accounted for by using solid lines, and non-significant relationships use a dotted line in both figures.

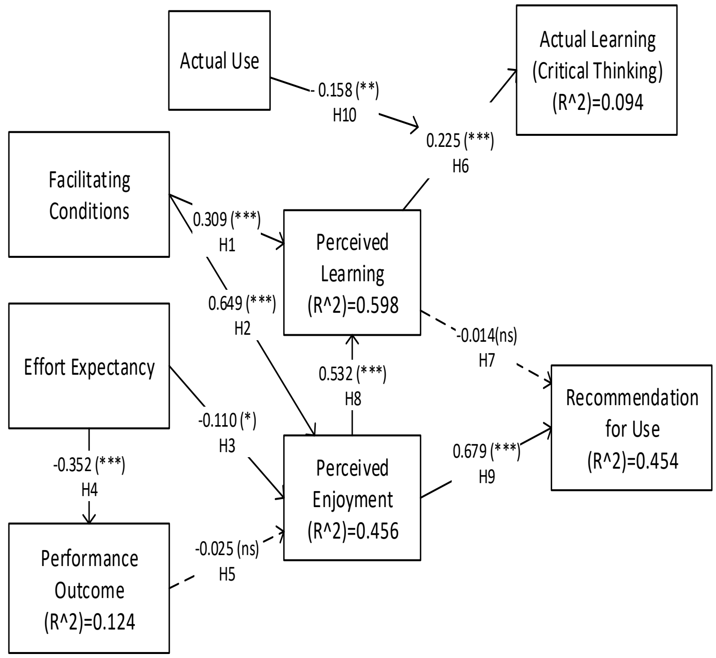


Figure 7.4 PL model pilot results.

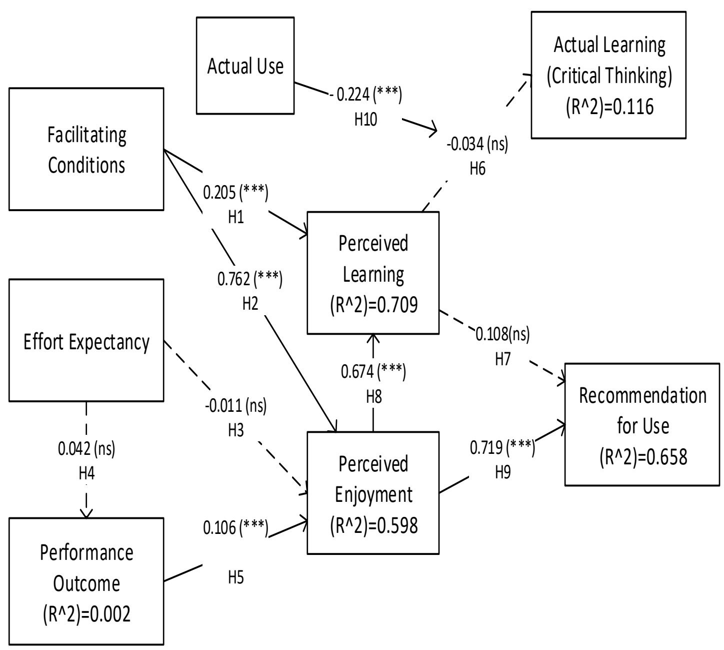


Figure 7.5 PL model main study results.
0.05 = *, 0.01 = **, 0.001= ***, ns = non-significant
Note: Inside the connecting arrows we show the β value known as the path coefficient.
Note2: The H10 arrow indicates a moderating effect in the relation between Perceived Learning and Critical Thinking.

Similar to the pilot study and the Wu, Hiltz and Bieber model, the following were supported.

1. HI: Students who perceived Improved Facilitating conditions will perceive increased learning
2. H2: Students who perceived higher Facilitating Conditions (FC) will perceive higher enjoyment.
3. H8: Students with higher perceived enjoyment will have higher perceived learning
4. H9: Students with higher perceived enjoyment will be more likely to recommend the approach.

The strongest relationships were between Facilitating Conditions (FC) for PL assignments and Perceived Enjoyment (PLe), and Perceived Enjoyment with both Perceived Learning (PLe) and Recommendation for Use (RU). All three relationships were positive with a path coefficient (strength of relationship) greater than 0.65. These relationships were also positive so as one measure increased, the other increased as well. For example, as students believed that the grading was fair and that the approach was well managed, they were more likely to enjoy their participation in the study. In addition, students who perceived higher enjoyment were more likely to recommend the use of the PL approach in the future but also report higher measures of learning. These findings have been consistent throughout in both Wu, Hiltz and Bieber model and the PL model as well. As students reported higher measures of enjoyment, they also were more likely to recommend the PL approach. This finding is consistent with feedback from student interviews in which students who expressed positive comments regarding the PL approach were more likely to express intention to recommend the system in the future.

There were other hypotheses that were found to be significant in this model that did not show as strong as a relationship. For H1, students who perceived improved Facilitating

Conditions had higher measures of Perceived Learning. This finding was also consistent with both Wu, Hiltz and Bieber model and the pilot study. However, the strength of the relationship was smaller in the main study.

In addition, the following hypothesis was supported in the main study but was not supported in the pilot study.

1. H5: Students with higher performance outcomes perceived a higher degree of enjoyment from the PL approach

Students with higher performance outcomes perceived a higher degree of enjoyment from the PL approach. Therefore, as students earned higher grades from the PL system, they reported higher measures of enjoyment in the course.

On the other hand, there were several hypotheses that were not supported.

1. H3: Students who perceive a higher degree of effort expectancy will derive less enjoyment from the PL approach
2. H4: Students who perceive a higher degree of effort expectancy will have lower performance outcomes.
3. H7: Students with higher perceived learning will be more likely to recommend the approach.

H3 was a hypothesis that was supported in the pilot study but was not supported in the main study. Thus, students who believed that the PL approach was more difficult did not necessarily report measures of lower enjoyment. In addition, if the opposite would have been true, then the relationship would still be significant and positive. H4 was also not significant. This finding was consistent with the results from the pilot study. It can be argued that an important aspect of Performance Outcome was access to students' PL grades given that the construct is entirely based on the grades students receive from their PL assignments. However, this was a limitation in the current website as despite added materials given students to guide students through the PL system, students still found it hard to navigate the site as expressed in their interviews. If a student could not easily find their grade, they would not be able to determine their performance so even if a student believed the course to be easy or difficult, they would not be able to determine how well they did difficulty finding their grades. Another unsupported hypothesis was H7, students with higher Perceived Learning were more likely to Recommend the Use of the PL approach. From student interviews, this can be explained by the fact that even if students did think the PL approach helped them learn more, they were still hesitant to recommend it in the future due to having issues with the website. Thus, it will be important to further improve the usability of the website so that students can not only access their grades (this was a common comment students expressed in interviews) and also ensure that the task pages are streamlined so that they know how to find the material needed to work on their assignments.

Sub-question #1.2: How can I extend the Wu, Hiltz, and Bieber theoretical model to account for actual learning (critical thinking) and system use?

In the pilot study, Perceived Learning did have a positive association with Actual Learning (measured through a critical thinking question given to students) and indicated a significant relationship in which students who believed to have learned more ended up having greater marks in their quizzes. In the main study, this relationship (H6) between Perceived Learning and Actual Learning (through critical thinking) was not significant. In addition, despite H10 being significant by having Actual Use moderate the effect of the relationship between Perceived and Actual Learning, this effect was negligible due to a very low path coefficient. An important issue raised during analysis was that the grades for critical thinking were not normally distributed (see Figure 7.6), with some courses performing better than others. Whereas a rubric was given to instructors to use, and expert graders were trained on how to use the rubric, there was a lack of consistency across the grading that significantly affected the results. Consequently, while grading was done by a single individual (either the instructor or expert grader) for each course for both treatment and control sections to ensure consistency within courses, there were some inconsistencies across sections that had grades that were on average lower or higher than others.

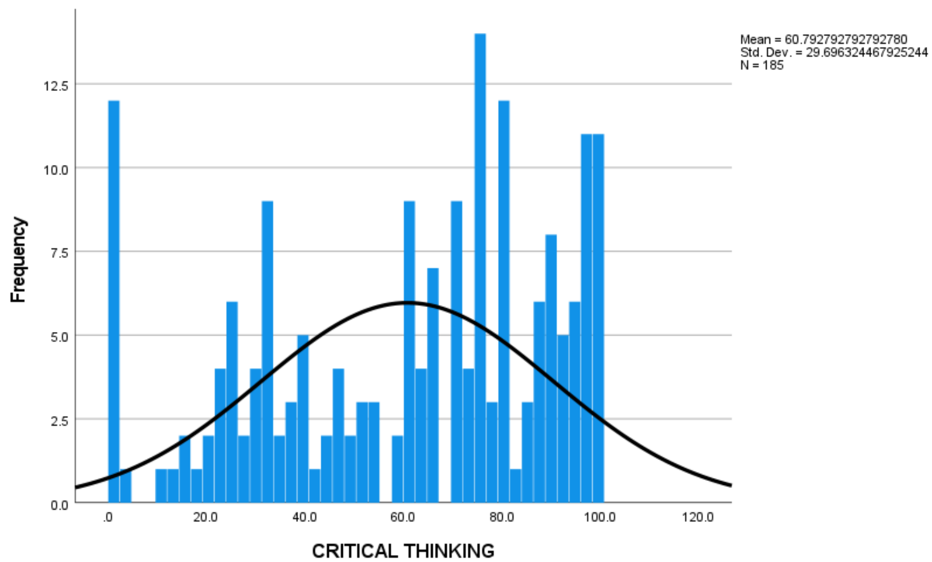


Figure 7.6 Treatment grade distribution**.**

Sub-question #2.3: How does microlearning affect the model?

For this main study, I worked with an instructor to have two microlearning sections and two treatment sections. For the microlearning sections, the PL assignments were broken down into smaller parts and given to students to work on before going back for review to the instructor. The treatment sections had longer assignments with longer deadlines. Ultimately, both assignments were about the same in length as the microlearning assignment was primarily based on the regular treatment assignment. For example, whereas a regular PL assignment would have a deadline of seven days from the day it was assigned, microlearning tasks that broke down the main task into two halves had consecutive deadlines of three to four days. To assess differences in the model and how the microlearning group would affect the relationship among the constructs, I conducted a Multi Group Analysis (MGA) on SPSS with 1000 bootstrapping samples with regular treatment and microlearning treatment as groups. In this section I will present the results from comparing 2 microlearning and 2 regular treatment sections from the same course. In the Multi Group Path coefficient test the path coefficients for both groups are calculated and then compared for significant differences across all the constructs. In Table C.118, there are some possible significant differences outlined due to the differences in conditions among the relationships in our model's constructs. However, out of all the possible relationships, only the differences between Performance Outcome and Perceived Enjoyment based on type of treatment were shown as significant. (See Table C.119.) In fact, the relationship as described in the output was inverse depending on the condition. In the regular treatment section, students who performed well in the PL assignment showed increased measures of enjoyment whereas in the microlearning section the relationship was inverse.

Nevertheless, due to the low number of microlearning sections and participants, results are not definitive and should be further studied. Nevertheless, the work done in this main study helps explore possible differences on relationships in the model based on the type of assignments (regular or microlearning) that students participated in.

7.3.3 Main Research Question #3

For Main Research Question #3, I asked: "Are there any significant differences in the effect in enjoyment, learning and critical thinking between students who experienced the PL approach and those who did not?" In the following analysis, I trimmed the data so that only treatment sections that had corresponding control sections were included in the analysis. This would help balance the number of participants in both conditions and allow for a more consistent comparison.

Sub-question #3.1: Are there any significant differences in perceived enjoyment between students who experienced and those who did not experience the PL approach?

About motivation, in the pilot study, 76.2% students in the control condition indicated that they were more motivated in the course, compared to 65.8% students in the treatment condition who agreed as well. However, the difference was also not significant (Chi-square = 6.61, P = 0.16). In the main study, 64.30% of students in the control condition indicated they were motivated in the course whereas 65% did in the treatment section. This difference was not significant according to Chi-Square and Independent T-test. (See Tables C.120, C.121, and C.122.)

In the pilot study, when asked: "Overall, I enjoyed this course", 76.3% of the students in the control condition (Mean = 4.21, SD=1.04) agreed that they enjoyed the course whereas only 67.5% did in the treatment condition (Mean = 3.83, SD = 1.22). In the main study, 66.30% agreed that they enjoyed the course in the treatment section against 64% in the treatment section. There was a significant difference according to the Chi-squared test (Chi-squared: 7.21, p: .012) but the T-test was not significant. (See Tables C.120, C.121, and C.122.)

Upon slicing the data further, it is shown that when comparing courses with at least a treatment and control section, students were more motivated in the control section. However, STEM 3 was the only course where students overall had a higher degree in motivation in the treatment section according to Table C.123. This result was similar to the pilot studies. Nevertheless, these results were not significant according to the Chi-square test. (See Table C.124.) In addition, comparing motivation by GPA level yielded not significant differences using Chi-square test according to Tables C.125 and C.126 except for students with low GPA. It should be noted that this was a small sample size for low GPA students so that significance determination needs to be done with cautiousness given unequal proportions.

Sub-question #3.2: Are there any significant differences in perceived learning between students who experienced and those who did not experience the PL approach?

In the pilot study, there was a significant greater perception of learning in the control section when compared to the treatment section. This difference was significant (Chi-square = 17.69, P = 0.001) at the 0.05 significance level. In fact, 88.7% of the students in the control condition in the pilot study (Mean = 4.50, SD = 0.80) felt that they learned a lot in this course, whereas only 78.6% did in the treatment group (Mean = 3.83, SD = 1.22).

In the main study, when sliced by course, the control conditions remain on par with the treatment courses. Still, in HUM 4, students showed greater perceived learning in the course than any other course section in the treatment condition. (See Table C.127.) It should be noted that rather than having PL be fully integrated with the assignment and handle the grading, the PL approach in this course was to allow students to provide formal feedback to each other while allowing for peer grading activities throughout the semester.

In addition, PL assignments in this section were graded primarily by participation with the grading component counting towards it. It can be argued that when students did not feel pressured in being evaluated, they felt more free to participate in the process.

Going back and comparing the treatment against the control section, the control section had a greater measure of perceived learning (72.8%, mean: 5.3) against treatment at (70.9%, mean:5.1). However, upon performing a t-test, the difference found was not significant at the 0.05 confidence level. We can thus conclude that although the control condition seemed to perform better in terms of perceived learning, this difference was not significant. (See Tables C.128 and C.129.)

Sub-question #3.3: Do students who participate in the PL approach improve their critical thinking skills when compared to those who do not participate?

The measure of critical thinking skill was done at end of semester through a critical thinking question given to students through an exam or quiz. When dicing the PL grades by condition and course section, there was a noticeable difference between grades across multiple courses. Whereas some sections had a mean of 30 points, others had a mean of 90. As explained earlier in the chapter, within the course section students' grades remained similar meaning that students in the class received around the same grade. Nevertheless, when comparing across sections some courses had overall higher average grades than others so the data was not normally distributed.

Finally, when comparing for significant differences between the control and treatment sections, the t-test showed that there were no significant differences between treatment (mean:64.5, SD:30.8) and control (mean:57.9, SD:32.5) despite the treatment doing better on average when taking the critical thinking question. (See Tables C.130, C.131 and C.132.) A final Two-way ANOVA test to explore critical thinking by condition and course type gave no significant differences. (See Table C.133.)

7.4 Discussion

This section will discuss the main findings and issues of the main study which built upon the initial pilot (preliminary) study. This discussion will be framed around what students thought of the current approach and the system that supported it, while also giving insights of current findings and how they can be used to advance the PL project to better serve future students. The following section lists several issues that the main study revealed. These will be expanded upon in Chapter 8 in the discussion of future research.

7.4.1. Participatory Learning Approach Reception

In RQ 1, an important question we had was how students in the treatment section would react to the PL approach by measures of perceived enjoyment, motivation, learning and recommendation. Based on the responses collected from students through surveys and interviews, I found that PL approach was overall well received by the students despite both the website's limitations and the circumstances surrounding the study.

Overall, despite difficulties explored below, the PL approach continued to be positively received by treatment students and thus provided additional insights to further improve the approach and the system. For example, most students enjoyed being part of the Participatory Learning approach for assignments. In addition, although all courses reported that the majority of students enjoyed the PL approach, the humanities courses significantly performed better the STEM courses in terms of enjoyment.

7.4.1.1 Issues with PL Process. An important issue that affected the treatment (and to a degree the control section), the COVID pandemic shifted how the pilot study operated in face-to-face classes to an online setting in the main study. This presented an important barrier as students took time to get used to online learning while also adjusting to their entire course load online. It should be noted that while interaction is done mainly online through the PL website, face to face communication is an important factor that needs to be further considered. In the case of students, for example, a student commented: "*Obviously with Covid I could not learn as much because we were not in the classrooms." (DS14)*. In the case of instructors, the lack of face-to-face interaction was also missed by students as instructors expressed difficulties getting used to or adapting to the PL approach through only online learning. For example, moving to online learning impacted professors who were used to assisting students' face to face either during class or immediately after it ended. This may have implications for using PL in online courses, requiring additional types of support for students, and this support may need to be different for synchronous vs. asynchronous courses. For synchronous courses, which was how the classes were given, it would require additional scaffolding for students to prepare them for the PL assignments beyond the initial introduction to the assignment. Instructional scaffolding refers to the process through which instructors can add support for students to enhance their learning. For the PL approach, providing additional aid to students to provide better grading and feedback will be important to improve peer feedback and assessment.

7.4.1.2 Ramifications for Future Studies. Additional scaffolding for PL sections would be an important addition to help students. For example, during the main study, students received additional materials and training 1) introduction to the PL approach on WebEx, and 2) several instructional documents including how to log into the system and update account, view tasks and view grades. However, it would be important to further train students on how to evaluate and provide feedback to each other. For example, preparing students to provide appropriate feedback and assessment would entail to providing additional training on rubric utilization so that they are able to more consistently assess each other. In addition, a comment students had was that there was a big difference in the quality of feedback received and thus it will be important to develop rubrics, training or exercises for students to be able to consistently give objective and actionable feedback that the reviewees can act upon to improve their work. Another suggested improvement would be to provide training to students in the PL approach through a test assignment that asks a very simple question. Students would not only need to be graded by quality of the responses but by completion and promptness so that they realize the need to take the assignment seriously. This would help ease struggling students into the PL assignments and ensure that they are all prepared for their first substantial assignments.

7.4.2. The Participatory Learning Model

Extending the discussion from the previous subsection, there were several difficulties that affected the study and the model developed. Whereas in the pilot study three of our ten hypotheses were rejected, in the main study there were four hypotheses that were rejected including one previously rejected in the pilot. Below I will explore some of the issues found and explore suggested changes for future studies.

7.4.2.1 Issues with PL Grades for Assignments and Critical Thinking. There was an issue with how the data was collected which stems from both the change of dynamics from face to face to online classes and the type of work (assignments) that the PL model aimed to evaluate. When applied to final examinations such as the original study by Wu, Hiltz and Bieber, there was only a single set of grades that students could easily find. However, in the case of assignments, due to the complexity of each assignment, and the amount of them, students ended up having many different grades that were confusing to them. One assignment could potentially have five grades including the two grades from the original graders, one additional grade from the grader consolidator, another grade from the dispute and a final grade from the instructor resolving the dispute.

There were issues with the PL assignment grades collected due to a lot of students grading other students leniently and thus causing most of grades to be allocated in the upper end of the range around 100. A student stated: *"I believe so, that most of the students were lenient in grading, you know how normally feels bad when you are grading someone. you don't want to give someone a bad grade. You want to be lenient with that, I did not like that part ... you could see how the graders were lenient." (DS1).*

Related to the critical thinking grades, issues that arose were related to the fact that the critical thinking questions were difficult to standardize due to the differences in topics between classes. Instructors and expert graders (who helped grade some sections that were not graded by the instructor) were given a rubric to grade critical thinking question. However, due to time constrains (to provide students with a final grade at end of semester), not all instructors appeared to have used the rubric as intended. Whereas the grading was relatively consistent across sections since it was the done by the same individual, there were courses that had on average high critical grades and other courses lower average critical thinking grades. Due to the issues with grading, these could thus explain some of the issues with validating the critical thinking hypothesis in the model.

7.4.2.2 Discussion of Issues with Hypotheses. Effort Expectancy was a single item construct that had a non-significant relation with Performance Outcome and a very weak relation with Perceived Enjoyment. Given that the survey question for Effort Expectancy was the same as the one in Wu, Hiltz and Bieber, there is the possibility that the connected constructs Performance Outcome (measured through PL grade which had issues as a variable) and Perceived Enjoyment (which included an additional measure of usability as we were testing a new system) may need to be revisited in the future to re-evaluate the questions. Nevertheless, in the current main study, the item loadings for each question that made up the constructs satisfied the threshold requirements as outline in Section 7.3.2,

Finally, the Perceived Learning and Recommendation for Use relationship was also not significant. This non-significant relationship needs to be revisited in the future given that Perceived Enjoyment did have a positive and strong relationship with both Perceived Learning and Recommendation for Use, and thus there might a confounding variable that is affecting that relationship.

Overall, despite the model failing to validate the hypotheses of several relations in the model, the hypotheses that did validate confirmed that several relationships of the UTAUT/TAM model did apply to assignments which was a different mode other than examinations.

7.4.2.3 Ramifications for Future Studies. The main study examined 495 subjects (those that consented to participate and submitted at least the first and third survey). However, there were more students who received support, were graded, and affected the process and that did not get accounted due to not consenting to the study. In addition, students received direct support through email and WebEx, and instructors received direct support when developing the initial PL assignment and then implementing it in the website. Therefore, managing the PL approach was labour intensive and thus must be considered when conducting future studies. Therefore, it would be more feasible time wise and a direct recommendation to focus on a smaller number of courses to better manage the process and grading. This is due to difficulties standardizing multiple sections from different courses and disciplines.

Since the PL approach was evaluated in a single semester, it can be argued that it will take students longer to manifest measures of increased critical thinking, especially if the students have only participated in a single assignment. Therefore, it would be interesting to evaluate the effect of PL over several semesters. Nevertheless, having students consent to participate throughout many semesters would present several challenges such as having students take classes that are implementing the PL approach. A suggestion would be to ask students in the surveys if it is their first time participating in the PL approach so that their results can be further evaluated.

Finally, the model should also be re-evaluated once additional data is collected in future semesters. Whereas the questions used ended up meeting the threshold values needed to be included in the model in the pilot and main study, a future study could seek to retest the current model and re-evaluate the questions used to measure the constructs.

7.4.3. Differences Between Treatment and Control

Ultimately, the results showed few to no significant differences between the treatment and control sections for perceived enjoyment, learning and critical thinking. It should be noted that even in both STEM and humanities courses that had in general lower perceived learning, enjoyment and recommendation scores in the treatment section, there were some instructors whose sections performed well such as HUM 3. This would thus indicate the possibility of an instructor effect in the study. From interacting with several instructors throughout the study, while all of them allowed the introduction of the PL system in their class, there were a few instructors that did get heavily involved with the PL approach. This provided additional support to the students as the instructor was able to provide more timely feedback and help which allowed the process to continue more smoothly. Whereas the treatment did better in critical thinking measures and the control did better in overall perceived learning and enjoyment, these differences were not significant.

7.4.3.1 Issues with PL Data and Management of Approach: Regarding GPA, to compare the treatment and control, the variable GPA was recoded based on the following ("High GPA" from 3.5001 to 4, "Medium" GPA from 2.001 to 3.5, "Low" GPA from 0 to 2; missing GPA was also coded). However, there were some particular items in the GPA variable that made the analysis difficult. For example, GPA had a central tendency at around 3.5 which indicated that the data used for the analysis could have been biased towards High GPA students who made up the largest grouping in the study. Using 3.5 as a cut-off for the groups helped make the proportions more even but also included a lot of students right below 3.5 in the medium category despite having a grade above average. This thus made it difficult to discern differences in conditions based on GPA as the participant's GPA was skewed. In addition, there was a particular observation with the GPA data regarding students receiving a 0 GPA and some receiving no GPA. This observation was brought up to the registrar office staff member who collected the GPA grades. The staff member responded that if a student (freshman or incoming transfer) did not have a GPA at the start of the semester, they would leave the field blank but if a student performed poorly that they would have a 0. Empirical observation of the GPA histogram seems to have a lot more students at 0 GPA than what would normally be expected so it would merit further review in the future.

Finally, as the study was conducted during the pandemic, introducing a new system that relied on other students to keep the process going could have added more anxiety to the students as they were dependent on others (peers) to have the work completed. There were comments from students who wanted the system to be more consistent in giving out tasks: *"I did not like, when people graded it, if they did not do it on time... I would be getting email at random times on the day, that I had a task due ... I look at my email. I got an email from the system, you have a task assigned ...If your assignment was late it came of as late. I had to do this done right away." (DS21)*. Because tasks from prior students in the assignment were late, students could not plan their schedule appropriately. Given that students might have been anxious at home, any additional stress from not receiving their tasks on time that the students in the treatment condition might have experienced could have contributed to diminished enjoyment and learning students.

Next I summarize why there may not have been significant differences between the treatment and control studies regarding perceived learning, enjoyment and critical thinking. First, we must consider that students participated in the PL approach during a single semester and for students' perceived learning, motivation and critical thinking to be affected it may take longer. Second, there were some courses that only had a single PL assignment throughout the semester and this could be another factor that minimized the possible effect of the PL approach. Third, students in the treatment sections had issues with the PL system that should be addressed so that students can focus their attention on the approach and their own learning rather than spending time learning to use the website. Fourth, as mentioned in Section 7.4.1, additional support for students regarding peer grading and feedback through training in rubric use would be important to ensure consistency in grading and improve feedback. These issues are addressed in the future work Sections 8.3.2 and 8.3.3 that would allow future studies to further study and re-evaluate differences between treatment and control.

Thus, it will be important to continue to work on further improving the PL protocol to account for student anxiety and devise ways to diminish its effect; students' lateness is an important issue that we must thus more actively account for.

7.4.3.2 Ramifications for Future Studies. There are some ramifications to the study that must be explored. First, similar to the issues brought in Sections 7.4.1 and 7.4.2, overall there will be a need to improve data collection for the grades. At the same time, further improvements to the system should be assessed to ensure that students in the treatment section do get support to get used to the PL approach and system. Suggestions to update the study in the future include further stablishing baseline rules across all sections regarding lateness of tasks. While there is a need to support professors and students who need to have the extra time to complete assignments, it will be important to also figure out ways to further improve the flow of the tasks so that the reallocation of tasks is further automated. For example, it will be important to more aggressively use students who have volunteered to do late tasks rather than waiting for late students to catch up. This is due to the fact that late students are further slowing down the process for the rest of the queue of participants in the assignment and negatively affect students. At the same time, as suggested earlier, reducing the number of courses for the researcher would help further manage the few selected courses throughout the semester to provide additional help. This would in turn allow the students in the PL treatment to further experience the approach which would allow us to collect more accurate measures. Finally, fixing the system will be important to account for students' issues including lack of the grade reporting feature: *"Honestly, I can't tell you if it got graded or not, I did not know if I got graded. I don't know which project was graded by who. I didn't know which student graded mine and did not know what grade I got for that assignment"* (DS19), need for improvement of the task page to avoid clutter and provide appropriate information as needed rather than displaying the entire assignment: *"I would definitely would say, a lot of clutter on the pages. It would be asking a lot. I do not think it needed the create task... just a drop box…"* (DS20), improve the file uploading feature to account for multi submissions and deletions: *"Another one, I had to do a two-step process to upload any file. I had to upload to my computer and click submit to upload it which I find weird. There is also another submit button to actually submit your task, I do not get, why I have to submit, twice for each file"* (DS25), and finally improve the late student replacement algorithm to further automate the process and ensure that students who completed their work get assigned their next task in a prompt manner.

7.5 PL System Improvements Recommendations

As a newly developed system, there were areas of the PL system (website) that students appreciated but also there were areas that students recommended be further improved. While there are specialized systems that allow for peer driven activities such as peer feedback and evaluation, the PL approach provided the ability to manage all the aspects of the assignment process from problem creation to grading. Due to its flexibility, the current feature set available can be further extended to provide improvements that can greatly help future research studies and the students that participate in them. Based on comments from instructors and students' interviews, the following are areas of improvements for the PL website. Findings are collected here:

1. Improve the current PL assignment task pages

    - Issue: Due to the PL needing to support complex assignments, when a task is assigned to a student, information that is displayed included relevant to the task and but also all other tasks the preceded it. For example, when someone is assigned a grading task, the student will get information on how to grade the task which included the rubric that quite often covered the entire screen due the high number of grading criteria some courses had. In addition, the students will also get information on the question and the corresponding solution along with all the instructions related to each task. Therefore, as assignments progress, the student gets information of the current task plus everything else worked on up to that point which presents a lot of information to the student. Students have commented that when they are presented that much information for the first time it takes them a while to figure out what to do as there is a lot of information to sort through. However, once they figure out that way information is displayed, then it becomes easier for them. Nevertheless, this is an area that can certainly be improved and that can benefit all of the students including those that do end up learning how to use well the PL system.

    - Suggestion: A suggestion would be to streamline the current task pages to include only relevant information such as previous user files by task. This would thus remove information not needed from previous assignments that are no longer needed while readily providing the files that the student needs to finish the task. In addition, currently the assignment task page splits all the tasks in tabs but does not specifically highlights the current task so it is easy for the students to get lost.

2. Improve the reporting of PL grades

    - Issue: Student have expressed issues with the lack of an easily accessible feature to display their grade. While students have been given instructions on how to review their grades from all the assignment status page, they have expressed frustration in the fact that it takes a lot of clicking to get to their grades, and once they are there they have to add up their scores individually to get their raw grade which they need to convert at the end if it's not out of 100. This thus cause trouble to students as they often do not know what their actual grade is.

- Suggestion: The grade report feature to show not only their final grade but also all relevant grades will be needed for future studies so that students can determine their performance in the assignments so they can provide better Performance Outcome measures. The grades students receive must be clearly outlined and easily accessible by students. This would include all their grades for each stage of the assignment and then the overall grade. Access through the dashboard would help students access their grades easily but the design should be careful to not overload that screen with too much information. However, since students use the dashboard to access their assignments and task, it would be important for the students to have a way to access their grades through that screen as well.

3. Improve handling of late PL tasks

    - Issue: Several students expressed concerns about not getting their assignments after their have submitted their task. In fact, students mentioned that they had to wait up for over a month to receive an old task due to others not doing their work. In addition, there were instances when tasks from multiple assignments overlapped due to the first assignment being completed as the second assignment was being assigned. Therefore, while not everyone, there was a group of students who expressed the need for more consistent scheduling of assignments so that they can plan their schedules in advance.

    - Suggestion: As a peer drive system, lateness is an issue that has been reduced by managing the process through volunteers to take on late tasks, and the removal of students who consistently do not do their work. However, while the initial reallocation of students has been automated, the subsequent stages still need to be automated as currently student reallocation after the first task has to be done manually. While the entire process does not necessarily need to be automated so that students who have valid reasons for being late are able to still participate in the process, an important update to the system would be to semi-automatically reallocate students at any point in the assignment rather than only at the very beginning For example, an instructor can set parameters for specific students to not be reallocated or taken out of the assignment cycle, and then have the system automatically replace the students on its own at specific periods of time. In addition, the system would also need to be able to handle replacing students who are late automatically with students from a volunteer pool rather than requiring to trigger the process manually as this would ultimately lead to added work for the instructor.

Other suggestions include integrating the PL system with CANVAS and other LMS. According to instructors and students, this would make it easier to manage the assignments as they would not need to check two separate websites. Finally, students expressed the need for better late notifications as currently if a student causes someone to be late, the student that is not at fault will still be notified about lateness. This would cause the students to worry about their grades being negatively affected. While students seemed to enjoy and perceive learning from the PL approach, the system can help further increase the effect but supporting the PL approach better.

Finally, from the findings listed, the important findings to generalize and include into future as updates or plugins for the PL website would include the following:

1. A grade report that allows students to easily access all the grades in their assignments including peer, self and instructor grades.
2. An assignment status tracker that is more intuitive and easily accessible by students from the PL dashboard.
3. A task page that includes only information for each activity to reduce information overload.
4. A notification manager that allows students to customize their assignment and task notifications.

Overall, in this section I have included suggestions to improve the PL system based on student and instructor interviews. In addition, throughout the study, issues that were brought up by students were noted and helped further guide this list of recommendations. The PL system is a new system which has great potential to improve student learning in assignments while facilitating the process to students, the current suggested changes aim to make the process easier for students to work on their assignments while further helping instructors manage the course.

7.6 Microlearning Case Study

In this case study, using descriptive statistics, I will describe the overall perception students had about their participation in the microlearning treatment condition. In this study, I had 2 sections with 25 students in total provide exploratory findings that would help us determine whether breaking down the assignment tasks into smaller chunks was perceived as beneficial to them. The following 4 questions were asked. It should be noted that these questions were only asked to the microlearning section and used a 7-item Likert scale with Disagree at 1 and Agree at 7. (See Table C.134.)

1. "I enjoyed that the PL stages (creating, solving, grading) were broken into multiple parts." (Mean:5.7, Median: 6, SD: 1.3)
    - Students overall agreed (60%) that they enjoyed that the assignment was broken into parts against those the disagreed (4%). Overall, this was the highest percentage of agreement from the 4 questions asked and indicates that the majority of students appreciated having large assignments broken into parts. A student mentioned "*Breaking down the parts and doing some in parts, like the first part and data. So I didn't have to worry about the instructions immediately after the data. So we would not be stressed out of doing the entire thing in one shot."* (DS8)
2. "I believe breaking down the PL stages into multiple parts was clearly explained." (Mean:5, Median: 5, SD: 1.4)
    - The majority of students agreed that the process was clearly explained to them (72%) when compared to students (12%) of students who disagreed
3. "Breaking down the PL stages into parts helps me have enough time to finish each task." (Mean:5.3, Median: 5, SD: 1.3)
    - Students overall agreed that breaking down the problems in parts helped them have enough time to finish each task (76%) when compared to (12%) of students who disagreed.
4. "It felt that breaking down the PL stages into parts added unnecessary extra work." (Mean:3.5, Median: 3, SD: 1.5)
    - The majority of students disagreed (52%) that breaking down the PL approach added unnecessary work against (28%) that agreed that it added work. However, a student in an interview shared: "*I liked it because*

> *everything was not done in one day. Towards the end, the last special assignment. I think he (professor) just submitted the whole thing, all at once … I think it can be a little unnecessary. But I think is kind of just easier to submit at once*.” (DS5).

After reviewing the responses from students who participated in the PL process, students overall had a very positive experience in the microlearning treatment section. These findings can therefore give instructors confidence that students would enjoy the microlearning approach and help with future instructor recruitment.

7.7 Case Study: HUM 3

A course that repeatedly performed well when compared to other courses in the treatment section was HUM 3. In this section, I will provide additional context to better describe the course and its activities.

HUM 3 is an ethics engineer course. The course focuses on major ethical perspectives of engineering in the wake of catastrophe to build services that benefit humanity. The major assignment had three parts: a draft with a thesis statement, an annotated bibliography and a final essay. There were weekly quizzes of which two were replaced as course assignments in the PL system. Rather than having the instructor give questions, students were coming up with the questions themselves. Students came up with questions for others to solve, while also solving someone else’s question similarly to a traditional PL assignment. Finally, the main PL assignment was a semester long project tied to a weekly guest-expert discussions done synchronously in class every Thursday. During Wednesday, the guest-experts would meet with the instructor to discuss the topic to cover the next day, in addition, they would submit questions to each other in the PL system. These questions would be answered and graded by other students. Thus, every week, students worked with each other to improve their presentation and then grade the quality of their responses to questions raised.

When HUM 3 was compared against STEM 3 and STEM 4, there were significant differences in perceived enjoyment and learning as HUM 3 performed better. For comparison purposes, STEM 3 and STEM 4 had very streamlined PL assignments which allowed students to finish them quickly and on time. Whereas the STEM courses did not experience any major issues, the assignments did not have the same degree of engagement or work requirements as HUM 3 where students needed to participate weekly in the guest panel assignment. In addition, from interviewing the instructor, he stated that he created and shared further support material customized with instructions relevant to parts of the assignment that students needed help with.

Therefore, there were two very clear aspects in which HUM 3 did things different: 1) the main project assignment ensured students consistently worked on the PL assignments throughout the semester and therefore were consistently working on it, and 2) the instructor provided additional help to students by tailoring his support material to his class needs. Ramifications for future studies relate to further studying how specific types of assignments would have an impact on the on students' perceptions about the PL approach and further explore possible instructor effect that could affect how students react to the PL approach.

7.8 Summary

In this chapter, I introduced the main study methodology, and discussed the methodology and changes from the pilot study. In addition, information about the data collected was detailed and findings derived were built upon the previous pilot work. Also, the discussion section covered the main findings of the study and built upon lessons learnt to explain issues found in the study. These issues were explained in the discussion section, including the ramifications for future studies. Finally, I presented additional system improvement recommendations, further examined the microlearning treatment section and presented additional insights about HUM 3.

CHAPTER 8

CONTRIBUTIONS, LIMITATIONS AND FUTURE WORK

The goal of this study was to evaluate the PL approach at courses at the university level. In order to do so, it builds up on previous research started by Wu, Hiltz and Bieber. Whereas the PL can certainly be extended beyond examinations and quizzes, in this section I will list only the contributions that reflect the research I have chosen to pursue. I do not include any contributions made by Wu, Hiltz or Bieber, nor by another member of the research or development teams.

8.1 Contributions

My initial contribution to the PL approach has been outlined in Section 1.2. In this section, I will recap and summarize the contributions. To provide some context, work related to the contribution will be included in this section as well. Finally, it should be noted that this dissertation was not primarily based on system development but rather the evaluation of the PL approach that was supported by a system. Therefore, this focused on answering the initial research questions presented and describing the methodology and process to evaluate changes in student perception regarding learning, motivation and recommendation of the approach.

Whereas I contributed to the design of the core features needed for the PL system, the focus of the work in this dissertation is on the research design, implementation and management of the PL approach in classes. For the pilot study, I worked with 4 instructors in 18 sections (7 control, 11 treatment). In the pilot, I conducted interviews after the semester ended with all instructors and 13 students. During the pilot study, as the main point of contact, I worked on managing the PL assignment creation and student task reallocations in addition to working with each instructor to create the course critical thinking questions and troubleshooting student issues. For the main study, I worked with 7 instructors in 31 sections (12 control, 17 treatments, 2 microlearning treatments). During the main study, I worked directly with instructors as the main point of contact to ensure the PL process went well. At the end of the semester, I conducted interviews with 6 instructors and 25 students. I worked on managing the entire process by meeting with every section to introduce the PL system, wrote additional documentation to help students, helped troubleshoot issues, implemented all PL assignments for the treatment and microlearning sections into the PL system, and created the critical thinking questions for each course. Finally, I oversaw the grading of the critical thinking question with the addition of expert graders for answers that were not graded by instructors. The results of this work are further explained the following subsections.

8.1.1. System Contribution

Although not the focus of this dissertation, a system contribution was the core design of the initial PL system that was later extended into the current PL system. This included front-end design of critical PL features such as the dashboard and task pages. The initial design was then tested for usability. In addition, I contributed to the design of the core PL database tables that have since been extended. For the current PL system, I conducted and analysed semi-structured interviews at the end of the semesters to collected feedback on the PL system. In addition, I have collected the system usability scores for the PL system for each semester to further compare improvement over time. Finally, feedback from students was collected which was used to help guide future design. The list of recommended system improvements has been described in Chapter 7.5. However, as outlined in Chapter 1, this dissertation was not primarily about system development so the focus will be on the PL approach and evaluation of the model.

8.1.2. Scientific Contribution

The focus of this dissertation has been on the experimental design and analysis in addition to the collection of feedback to guide future studies. From the IS perspective. my research extends the model created by Wu, Hiltz and Bieber [2]. This is achieved through the inclusion of additional constructs to the original model. As part of my contributions, I tested the PL model in assignments at multiple courses in STEM and Non-STEM disciplines. The PL model included the original constructs from Wu, Hiltz and Bieber in addition to measures of critical thinking and system use. I also explored an additional condition that used microlearning on assignments and included its effects in the previous discussion section. From an educational perspective, I also explored the PL approach to assignments using a control section to evaluate learning effects from participating in the PL approach. This work can therefore help guide instructors at the university and other educational levels.

It should be noted that although the system will be available for use, it is not a primary focus or a direct contribution of the study. Nevertheless, material developed to promote the PL approach are direct contributions and will be made available to help instructors develop their own PL assignments and critical thinking questions. For example, one aspect of this is to convert assignments from their traditional to PL equivalent which is further described in Appendix D.

8.2 PL Limitations

There have been several limitations to the study that will be outlined in this section.

8.2.1 COVID-19 Pandemic

The pandemic had a direct impact on the PL study. Initial data from the pilot study was collected in face-to-face classes and with the lockdowns that happened throughout the year, students were affected as their learning environment suddenly changed. In addition, due to the sudden changes in the classroom environment it was more difficult to provide assistance to participants who were not used to working online.

8.2.2 Generalizability

The main study was conducted primarily in a distance learning setting using the PL website to manage the assignment process. Therefore, careful consideration must be taken when extending the results of this study due to the differences in both face to face and online education. Nevertheless, findings from this study can still be generalized to online learning courses due to sizable amount of STEM and Non-STEM courses that participated in the study.

8.2.3 Confounding Effects

Based on the analysis of the data in the main study, there are possibly some confounding variables in the study with several confounding effects that affected the main study results.

Instructor effects is the primary confounding effect due to how there were specific courses that seemed to outperform other courses. For these courses, the instructor played an important role in managing the approach and helping students participate in the PL approach. In particular, instructors that seemed very involved with the PL process seemed to motivate students and had students who reported higher perceived learning measures.

Incentive effect was another confounding variable that was present due to the varying degrees of extra credit that students received from participating in the study. The extra credit was an incentive for students to complete the surveys and interviews which helped the study greatly by allowing the collection of data.

Finally, regarding qualitative data from interviews, it should be acknowledged that there is the possibility of bias due to the subjects not being randomly chosen but rather volunteering their time to participate in the interviews for extra credit. For example, it can be argued that as students who participated in the interviews were primarily motivated by the extra credit grades, their views may reflect those who put additional emphasis on their own grade which might not be representative of the entire class. Nevertheless, the interviews from students were polarized with students giving either very positive or very negative reviews about the PL system and approach. However, there were interesting findings derived from students with negative feedback that could further help us improve the system and approach.

8.2.4 PL System

Based on student comments and data collected through interviews and surveys, the students' overall experience in the PL approach could have been improved. As the PL system (website) was separate from the course learning management system, students were required to use two different systems. Having to use two systems could have potentially been disruptive for students and thus must be acknowledged as a limitation in the study. For example, students had to log into their regular online course website to access instructions for assignments and then had to use the PL website to complete their assignment tasks. Finally, the grades of students were not directly exported to their LMS gradebook and thus students had to go back to the website to access their grades. From interviews, students and instructors expressed interest in having the PL system be integrated with their online learning space so that all the learning resources are consolidated in a single place.

In addition, students had difficulty navigating through the assignments due to the amount of information presented to them. Finally, an important feature that is currently missing was the grade report feature which allow students to review their grade easily. Students also expressed difficulties finding their grades despite additional instructions given to them. Addressing the limitations of the PL system will be important to ensure students can have a better experience when participating in the PL approach.

8.2.5 Lack of Longitudinal Data

An important issue raised has been that the study aims to test for measures of increased critical thinking on students that may only use the PL system for a single assignment. Therefore, evaluating students over time as they engage in the participatory learning process would help provide additional insights on how much participation in the PL approach would help students learn while also motivating them.

8.2.6 Peer Grading and Feedback

There were some issues with how students were grading each other during the study which could lead to inaccurate grades. The PL approach relies on students evaluating each other and therefore providing in-depth training on how to assess others would help improve the consistency in the grades collected. Another possible improvement would be having students grade the quality of their peers' grading and thus it would be important to train students on these activities as well.

8.3 Future Work

8.3.1 Further analysis of the main study data collected, and model

Further analysis of the main study data would include additional testing for differences between treatment and control by other categories such as gender and number of online classes. In addition, the repeated measures, although not a complete set as there were some students that did not fill survey 2, could be further analyzed to determine differences over time on the major constructs including perceived learning, perceived enjoyment, and measures of cognitive and affective learning.

Also, while the data results are very similar across the pilot and main studies, a formal analysis for significance across the main construct's variables will be important. However, is should be noted that the Likert scales used for the pilot and main study were different with scales from 1 to 5 in the pilot and 1 to 7 in the main study. Furthermore, there would be a need to standardize both datasets to have a common measurement scale for comparison.

8.3.2 System Future Work

An outline of recommended suggestions was presented in Chapter 7.5. To summarize the findings, based on the feedback received through interviews and comments, key improvements to the PL system would include improving the navigation across page information when completing tasks while also aiming to reduce information overload on the students. This would allow students to find the information relevant for their task in the assignment screen. In addition, a repeated comment by several students was that they could not find the uploaded files in the PL task pages due to the amount of information displayed to them. Also, instructors mentioned that to help them manage the process better, having access to student grades in the PL system would allow them to evaluate their class better. Another important update to the system would be the implementation of better file upload tools so that students can upload multiple files at once while not having to individually remove them when they made a mistake. Finally, the integration of the PL system within current LMS would help instructors manage the process better and also help students ease into the PL approach by allowing them to work on their assignments inside their usual online course workspace.

8.3.3 Scientific Future Work

For scientific future work, it will be important to better manage the process. An important aspect would be to retest the PL model under similar conditions in a face-to-face setting in a future study to better mirror and validate the findings from the pilot. Furthermore, improvements on other aspects of the PL approach are outlined below.

1. Provide additional training to teach students on how to grade and evaluate each other so that the grades given can better reflect the work done by the person being evaluated. Providing additional scaffolding to students would certainly improve the quality of the data collected.
2. Standardize the grading of the critical thinking question so that this measure can better reflect critical thinking improvement on students.
3. Conduct a formal evaluation of the degree of cognitive load and difficulty for each PL assignment which could help determine if the difficulty of PL assignments could affect student perceptions about the PL approach.
4. Conduct longitudinal studies related to the PL approach to evaluate changes over

time. It can be argued that students who only did the PL approach once during the semester would have difficulty increasing their critical thinking in addition to having minimal increase perceived learning, enjoyment and recommendation measures due to minimal exposure to the PL approach. In addition, future studies should include additional survey questions to determine which students may have participated previously in the PL approach. This would provide us additional information regarding perceived changes over time.

To better serve and collect data from students, as well as having time to conduct the research more effectively, rather than focusing on multiple smaller sections it would be ideal to focus on a smaller number of sections with a larger number of students. Focusing on less courses would allow to further manage the process while providing additional help for students to manage the process.

8.4 Summary

The Participatory Learning approach provides opportunities to students to actively engage in most aspects of assignments by managing the process for instructors. In the context of this dissertation work, there was a preliminary study that aimed at testing the instruments for the main study while evaluating the system to suggest future improvements. In the main study, the three main research questions were reviewed to further validate the pilot results or expand on early findings based on the data collected. Based on the main study results, it was found that students did enjoy and learned from the PL approach for course assignments.

The work done as part of this dissertation will help provide instructors with comparison data across the treatment and control sections for learning. In addition, it also provides additional information on how to further measure actual learning through a critical thinking question. This question tested students higher order cognitive skills across sections and should be further refined. Recommendations for future work include improving the PL support website, the study protocol and further evaluating the research model. PL has the potential to change the way students engage with their peers and assignments, thereby improving their critical thinking across many disciplines at the university level.

APPENDIX A

PL MODEL QUESTIONS

This appendix contains information about the questions used to collect the information about the PL model.

A.1 Facilitating Conditions Questions

Clarity of the Tasks:

(Part 1, Q12) The *problem & solution guidelines* given by the instructor are explicit enough.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1, Q13) The *grading criteria & guidelines* given by the instructor are explicit enough.

a. Strongly Disagree
b. Agree
c. Neutral
d. Disagree
e. Strongly Agree

Perceived Fairness:

(Part 1, Q9) I felt the grading process was fair.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1, Q11) I don't think students were capable of grading the solutions to the problems they designed.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Degree of Instructor Help

(Part 1, Q10) The instructor coordinated the PL approach well.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 3, Q11) (Putting PL aside) What's your evaluation of the overall teaching ability of your instructor.

a. Highly Unsatisfactory – 1
b. 2
c. 3
d. 4
e. Highly Satisfactory 5

A.2 Effort Expectancy Questions

Perceived degree of difficulty

(Part 3, Q4) How easy or difficult did you EXPECT this course to be?

a. Easy – 1
b. 2
c. 3
d. 4
e. Difficult - 5

(Part 3, Q5) How easy or difficult do you FIND this course is?

a. Easy – 1
b. 2
c. 3
d. 4
e. Difficult - 5

(Part 3, Q6) What grade do you expect to receive in this course?

a. A
b. A-
c. B+
d. B
e. B-
f. C+
g. C
h. C-
i. D
j. F
k. Incomplete

A.3 Perceived Enjoyment Questions

Perceived ease of use (System Usability Scale)

Use this scale: (Strongly Disagree) 1 – 2 – 3 – 4 – 5 (Strongly Agree)

- (Part 1.Q21). I think that I would like to use this system frequently.
- (Part 1.Q22). I found the system unnecessarily complex.
- (Part 1.Q23). I thought the system was easy to use.
- (Part 1.Q24). I think that I would need the support of a technical person to be able to use this system.
- (Part 1.Q25). I found the various functions in this system were well integrated.
- (Part 1.Q26). I thought there was too much inconsistency in this system.
- (Part 1.Q27). I would imagine that most people would learn to use this system very quickly.
- (Part 1.Q28). I found the system very cumbersome to use.
- (Part 1.Q29). I felt very confident using the system.
- (Part 1.Q30). I needed to learn a lot of things before I could get going with this system.

Perceived Flexibility

(Part 1, Q16) I enjoyed the flexibility that the PL approach allowed in organizing my resources.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Pressure

(Part 1. Q14) The time allowed for the PL assignments was sufficient.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1. 17) I felt under much pressure doing assignments this way.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Anonymity

(Part 1, Q20) .I liked that nobody knew who wrote each task.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Facilitation of Process

(Part 1, Q31) The online PL web site made the PL approach easy to do.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Motivation

(Part 2, Q5) During this course, I was stimulated to do additional reading.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q7) During this course, I was motivated to do my best work.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q14). Overall, I was motivated in this course.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Enjoyment of PL approach

(Part 1, Q33) I enjoyed the PL approach

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Overall Enjoyment

(Part 2, Q15) Overall, I enjoyed this course.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 3, Q12) Thinking about your own self-assessment of your work and assignments,

what's your evaluation of this course:

a. Highly Unsatisfactory
b. Unsatisfactory
c. Neutral
d. Satisfactory
e. Highly Unsatisfactory

A.4 Perceived Learning Questions

Perceived Overall Learning

(Part 3. Q10) (Putting the PL web site and approach aside) What's your evaluation of the overall educational value of this course:

a. Highly Unsatisfactory – 1
b. 2
c. 3
d. 4
e. Highly Satisfactory 5

(Part 2, Q1) During this course, my skill in critical thinking to solve problems has increased.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q2) During this course, my ability to comprehend information has increased.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q3) During this course, my ability to articulate and write a well thought-out solution has increased.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q4) During this course, my ability to integrate facts and develop generalizations improved.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q6) During this course, I learned to value other points of view.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 2, Q16) Overall, I learned a lot in this course.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Perceived Learning Scale (CAP Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

Use this scale: (Not at all) 0– 1 – 2 – 3 – 4 – 5 – 6 (Very much so)

- (Part 2, Q8) I can organize course material into a logical structure.
- (Part 2, Q9) I cannot produce a course study guide for future students.
- (Part 2, Q10) I have changed my attitudes about the course subject matter as a result of this course.
- (Part 2, Q11) I can intelligently critique the texts used in this course.
- (Part 2, Q12) I feel more self-reliant as the result of the content learned in this course.
- (Part 2, Q13) I feel that I am a more sophisticated thinker as a result of this course.

About Participatory Learning Approach

(Part 1. Q1) I learned from having to make up problems.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1. Q2) I used real-world scenarios in designing and/or solving problems.

a. Yes (Answer question 3)
b. No (If no, go to question 4)

(Part 1, Q3) Using real-world scenarios increased my learning

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1, Q4) I learned from solving problems with the PL approach.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1. Q5) I learned from grading other students' solutions.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1, Q6) I learned from reading other people's problems, solutions and grading

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part1, Q7) The PL approach enabled me to demonstrate what I learned in this course.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part1, Q8). I don't think students were able to design good problems for learning in this course.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

Part 1, Q15) The PL approach causes me to synthesize (connect/put together) different things I know.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1. Q32) Overall I feel the PL approach helped me learn more.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

A.5 Recommendation for Use Questions

Recommendation for Use

(Part 1. Q18) I would rather use PL for *assignments* instead of the traditional approach.

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

(Part 1. Q34) Would you recommend in the future that the PL approach be used for this course and its assignments?

a. Strongly Oppose
b. Disagree
c. Neutral
d. Agree
e. Strongly Recommend

A.6 Core Critical Thinking Skills

Table A.6a Core Critical Thinking Skills Part 1

Core Critical Thinking Skills :[87]		
SKILL	Experts' Consensus Description	Subskill
Interpretation	"To comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria."	Categorize Decode significance Clarify meaning
Analysis	"To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express belief, judgment, experiences, reasons, information, or opinions"	Examine ideas Identify arguments Identify reasons and claims
Inference	"To identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to reduce the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation"	Query evidence Conjecture alternatives Draw logically valid or justified conclusions
Evaluation	"To assess the credibility of statements or other representations that are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions, or other forms of representation"	Assess credibility of claims Assess quality of arguments that were made using inductive or deductive reasoning

Source: P. A. Facione [87]

Table A.6b Core Critical Thinking Skills Part 2

Core Critical Thinking Skills :[87]		
SKILL	Experts' Consensus Description	Subskill
Explanation	"To state and to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments"	State results Justify procedures Present arguments
Self-Regulation	"Self-consciously to monitor one's cognitive activities, the elements used in those activities, and the results educed, particularly by applying skills in analysis, and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results"	Self-monitor Self-correct

Source: P. A. Facione [87]

A.7 Interview Questions

Hello, thank you very much for coming, my name is Erick and I work with Professors Michael Bieber and Roxanne Hiltz on the Participatory Learning Approach (PL) research.

Today we will talk about your experiences with the PL system. There is not a right or wrong answer as we are hoping to get a broad array of perspectives. We will begin with some background questions and then we will go in more depth about your experiences with the PL system this semester. If you have any questions before we begin please let me know. If you feel like you don't want to answer a question we can just skip over it. Before we continue I would like you to sign this consent form.

1. Can you describe how is a typical college day for you?
2. Could you walk me through a typical classroom period here at NJIT?

You have the chance to try out the PL system this semester to work on your assignments, let's talk a little bit more about your experiences with it.

3. Overall, how would you describe your experience with the PL system?
4. Could you walk me through a typical PL assignment you did while in class?
5. Was there anything you liked about the PL approach? Could you explain why?
6. Was there anything you did not like about the PL approach? Could you explain why?
7. Did making up a problem help you learn in any way? Why or why not?
8. Did solving someone else's problem help you learn in any way? Why or why not?
9. Did grading others help you learn in any way? Why or why not?
10. Did reading someone else's work helped you learn in any way? Why or why not?
11. Was there anything you liked about the length of the assignment? Could you explain why?
12. Was there anything you disliked about the length of the assignment? Could you explain why?
13. Was there any difference in learning from having the task being short? Could you explain why?

We are about to finish; we have a couple of more questions.

APPENDIX B

PILOT (PRELIMINARY) STUDY RESULTS

In this appendix, I will include information in tables relevant to the pilot (preliminary) study.

Table B.1 Participants (Students) in Each Course

				Count
Alpha	Fall 2018	Control	PHIL 334	38
		Treatment	PHIL 334	19
	Spring 2018	Control	PHIL 334	45
		Treatment	PHIL 334	48
			PHIL 334	23
	Spring 2019	Control	PHIL 334	42
		Treatment	PHIL 334	36
Bravo	Fall 2019	Treatment	CS 288	61
Charlie	Fall 2018	Control	MIS 1045	19
		Treatment	MIS 1045	20
	Fall 2019	Control	MIS 1045	10
		Treatment	MIS 1045	14
			MIS 1045	14
			MIS 1045	17
Delta	Fall 2018	Control	MIS 1045	17
		Treatment	MIS 1045	17
	Fall 2019	Control	MIS 1045	14
		Treatment	MIS 1045	20

Table B.2 Professor Alpha Course Grades

Professor				Course Grade Mean	Count
Alpha	Spring 2018	Control	PHIL334	88.56	45
		Treatment	PHIL334	89.43	48
			PHIL334	90.82	23
	Spring 2019	Control	PHIL334	91.69	42
		Treatment	PHIL334	89.03	37
	Fall 2018	Control	PHIL334	83.85	38
		Treatment	PHIL334	86.86	19

Table B.3 Professor Bravo Course Grades

Professor				Course Grade Mean	Count
Bravo	Fall 2019	Treatment	CS 288	43.29	61

Table B.4 Professor Charlie Course Grades

Professor				Course Grade Mean	Count
Charlie	Fall 2018	Control	MIS 1045	73.39	19
		Treatment	MIS 1045	72.65	20
	Fall 2019	Control	MIS 1045	NP	10
		Treatment	MIS 1045	NP	14
			MIS 1045	NP	14
			MIS 1045	NP	17

NP: Instructor did not provide data.

Table B.5 Professor Delta Course Grades

Professor				Course Grade Mean	Count
Delta	Fall 2018	Control	MIS 1045	NP	17
		Treatment	MIS 1045	NP	17
	Fall 2019	Control	MIS 1045	NP	14
		Treatment	MIS 1045	NP	20

NP: Instructor did not provide data.

Table B.6 Professor Alpha Course Grade, PL Score (Treatment Only), and Gender

Professor						Mean	SD	N
Alpha	Spring 2018	Control	PHIL334	PL Final Score		NP	NP	45
				Course Grade		88.6	13.94	45
				Gender	Female			10
					Male			35
		Treatment	PHIL334	PL Final Score		91.1	28.0	48
				Course Grade		89.43	11.54	48
				Gender	Female			10
					Male			38
			PHIL334	PL Final Score		91.3	24.6	23
				Course Grade		90.82	9.20	23
				Gender	Female			1
					Male			22
	Spring 2019	Control	PHIL334	PL Final Score		NP	NP	42
				Course Grade		91.69	13.28	42
				Gender	Female			5
					Male			37
		Treatment	PHIL334	PL Final Score		77.2	28.8	37
				Course Grade		89.03	10.37	37
				Gender	Female			9
					Male			28
	Fall 2018	Control	PHIL334	PL Final Score		NP	NP	38
				Course Grade		83.85	16.48	38
				Gender	Female			10
					Male			26
					Other			2
		Treatment	PHIL334	PL Final Score		92.8	14.0	19
				Course Grade		86.86	10.92	19
				Gender	Female			2
					Male			15
					Other			2

NP: Instructor did not provide data.

Table B.7 Professor Bravo Course Grade, PL Score (Treatment Only), and Gender

Professor						Mean	SD	N
Bravo	Fall 2019	Treatment	CS 288	PL Final Score		44.9	34.6	61
				Course Grade		43.29	17.61	61
				Gender	Female			8
					Male			52
					Other			1

Table B.8 Professor Charlie Course Grade, PL Score (Treatment Only), and Gender

Professor						Mean	SD	N
Charlie	Fall 2018	Control	MIS1045	PL Final Score		NP	NP	19
				Course Grade		73.39	9.38	19
				Gender	Female			5
					Male			14
		Treatment	MIS1045	PL Final Score		86.2	20.2	20
				Course Grade		72.65	19.89	20
				Gender	Female			4
					Male			16
	Fall 2019	Control	MIS1045	PL Final Score		NP	NP	10
				Course Grade		NP	NP	10
				Gender	Female			2
					Male			8
		Treatment	MIS1045	PL Final Score		NP	NP	14
				Course Grade		NP	NP	14
				Gender	Female			5
					Male			9
			MIS1045	PL Final Score		NP	NP	14
				Course Grade		.NA	NP	14
				Gender	Female			3
					Male			11
			MIS1045	PL Final Score		NP	NP	17
				Course Grade		NP	NP	17
				Gender	Female			9
					Male			7
					Other			1

NP: Instructor did not provide data.

Table B.9 Professor Delta Course Grade, PL Score (Treatment Only), and Gender

Professor						Mean	SD	N
Delta	Fall 2018	Control	MIS1045	PL Final Score		NP	NP	17
				Course Grade		NP	NP	17
				Gender	Female			6
					Male			11
		Treatment	MIS1045	PL Final Score		87.2	25.1	17
				Course Grade		NP	NP	17
				Gender	Female			6
					Male			11
	Fall 2019	Control	MIS1045	PL Final Score		NP	NP	14
				Course Grade		NP	NP	14
				Gender	Female			4
					Male			10
		Treatment	MIS1045	PL Final Score		67.2	23.3	20
				Course Grade		NP	NP	20
				Gender	Female			5
					Male			15

NP: Instructor did not provide data.

Table B.10 Results for Number of Online Courses Taken

			Group Type		
			C	T	R
How many online courses have you taken?	1	N	21	39	60
		%	11.40%	13.50%	12.70%
	2-4 others	N	48	71	119
		%	25.90%	24.60%	25.10%
	5 or more	N	110	171	281
		%	59.50%	59.20%	59.30%
	None	N	5	8	13
		%	2.70%	2.80%	2.70%
	Prefer not to answer	N	1	0	1
		%	0.50%	0.00%	0.20%

Note: C= Control, T=Treatment, R=Total

Table B.11 Pilot Study Facilitating Conditions Results

		1 Disagree	2	3	4	5 Agree	Total	
		%	%	%	%	%	Mean	SD
Clarity of the Tasks	The *problem & solution guidelines* given by the instructor are explicit enough.	1.0%	7.3%	19.0%	36.7%	36.0%	3.99	.97
	The *grading criteria & guidelines* given by the instructor are explicit enough.	1.4%	3.5%	21.5%	35.3%	38.4%	4.06	.93
Perceived Fairness	I felt the grading process was fair.	1.0%	5.9%	23.5%	36.7%	32.9%	3.95	.95
	I don't think students were capable of grading the solutions to the problems they designed.	13.8%	28.0%	32.2%	18.0%	8.0%	2.78	1.14
Degree of Instructor Help	The instructor coordinated the PL approach well.	4.2%	8.3%	20.1%	32.2%	35.3%	3.86	1.12
	What's your evaluation of the overall instructor teaching ability?	Unsatis-factory 5.9%	9.0%	16.3%	26.3%	Satis-factory 42.6%	3.91	1.21

Table B.12 Pilot Study Effort Expectancy Results Part 1

		1 Easy	2	3	4	5 Difficult	Total	
							Mean	SD
Perceived degree of difficulty	How easy/difficult did you expect this course to be?	9 %	18.3 %	27.7 %	23.9 %	21.1 %	3.31	1.2
	How easy/difficult do you find this course is?	8 %	16.6 %	31.1 %	23.2 %	21.1 %	3.34	1.2

Table B.13 Pilot Study Effort Expectancy Results Part 2

Perceived degree of difficulty	
	What grade do you expect to receive in this course?
A	42.60%
A-	10.40%
B+	9.70%
B	10.70%
B-	3.80%
C+	10.00%
C	5.20%
C-	2.80%
D	1.00%
F	0.30%
Prefer not to answer	3.50%

Table B.14a Pilot Study Perceived Enjoyment Results Part1

		1 Disagree	2	3	4	5 Agree	Total	
		%	%	%	%	%	Mean	SD
Usability Scale	I think that I would like to use this system frequently	9.70	17.30	28.00	29.10	15.90	3.24	1.2
	I found the system unnecessarily complex.	16.60	30.10	23.20	16.30	13.80	2.81	1.28
	I thought the system was easy to use.	7.30	16.30	21.80	28.00	26.60	3.51	1.25
	I think that I would need the support of a technical person to be able to use this system	36.00	26.60	16.60	14.50	6.20	2.28	1.26
	I found the various functions in this system were well integrated.	6.90	12.10	33.60	29.10	18.30	3.4	1.13
	I thought there was too much inconsistency in this system.	14.50	28.70	22.80	18.30	15.60	2.92	1.29
	I would imagine that most people would learn to use this system very quickly.	4.50	8.30	29.80	33.90	23.50	3.64	1.07
	I found the system very cumbersome to use.	16.30	21.10	33.60	18.3	10.70	2.86	1.21

Table B.14b Pilot Study Perceived Enjoyment Results Part2

		1 Disagree	2	3	4	5 Agree	Total	
		%	%	%	%	%	Mean	SD
Usability Scale	I felt very confident using the system.	5.50	13.50	26.00	34.30	20.80	3.51	1.13
	I needed to learn a lot of things before I could get going with this system.	22.50	27.00	27.30	15.60	7.60	2.59	1.21
Perceived Flexibility	I enjoyed the flexibility that the PL approach allowed in organizing my resources.	4.20	10.40	25.60	32.2	27.70	3.69	1.11
Perceived Pressure	The time allowed for the PL assignments was sufficient.	4.80	9.70	18.00	30.80	36.70	3.85	1.16
	I felt under much pressure doing assignments this way.	15.20	28.40	27.00	18.70	10.70	2.81	1.22
Perceived Anonymity	I liked that nobody knew who wrote each task.	3.10	4.80	19.40	19.40	53.30	4.15	1.09
Perceived Facilitation of Process	The online PL web site made the PL approach easy to do.	5.90	10.00	34.60	30.40	19.00	3.47	1.09

Table B.14c Pilot Study Perceived Enjoyment Results Part3

		1 Disagree	4	5		Agree	Total	
		%	%	%	%	%	Mean	SD
Perceived Motivation	During this course, I was stimulated to do additional reading.	6.90	12.80	22.50	26.00	31.80	3.63	1.24
	During this course, I was motivated to do my best work.	3.50	4.50	18.30	35.60	38.10	4	1.03
	Overall, I was motivated in this course.	5.90	8.70	19.70	32.90	32.90	3.78	1.17
Perceived Enjoyment of PL approach	I enjoyed the PL approach.	8.70	10.70	26.30	31.80	22.50	3.49	1.2
Perceived Overall Enjoyment	Overall, I enjoyed this course.	6.60	9.00	17.00	29.40	38.10	3.83	1.22
	What's your evaluation of this course?	Unsatis-factory 1.40	5.50	19.70	34.30	Satis-factory 39.10	4.04	0.97

Table B.15a Pilot Study Perceived Learning Results Part 1

		1 Disagree	2	3	4	5 Agree	Total	
		%	%	%	%	%	Mean	SD
About Participatory Learning Approach	I learned from having to make up problems.	2.40	6.60	26.0	33.90	31.10	3.85	1.02
	I learned from solving problems with the PL approach.	4.50	8.30	28.00	36.30	22.80	3.65	1.06
	I learned from grading other students' solutions.	8.30	8.70	21.10	32.20	29.80	3.66	1.22
	I learned from reading other people's problems, solutions and grading.	5.20	8.00	19.40	30.80	36.70	3.86	1.15

Table B.15b Pilot Study Perceived Learning Results Part 2

		1 Disagree	2	3	4	5 Agree	Total	
		%	%	%	%	%	Mean	SD
About Participatory Learning Approach	The PL approach enabled me to demonstrate what I learned in this course.	4.20	6.90	19.00	36.30	33.60	3.88	1.08
	I don't think students were able to design good problems for learning in this course.	13.50	27.70	32.90	15.90	10.00	2.81	1.16
	The PL approach causes me to synthesize (connect or put together) different things I know.	3.50	6.60	26.30	33.60	30.10	3.8	1.05
	Overall I feel the PL approach helped me learn more.	7.60	10.70	26.30	36.00	19.40	3.49	1.15

Table B.16 Pilot Study Recommendation for Use Results

		1 Disagree	2	3	4	5 Agree	Total	
							Mean	SD
Recommendation for Use	I would rather use PL for *assignments* instead of the traditional approach.	12.8%	18.7 %	31.8 %	23.5 %	13.1%	3.06	1.21
	Would you recommend in the future that the PL approach be used for this course and its assignments?	Oppose 3.8%	12.1 %	31.1 %	40.1 %	Reco-mmend 12.8%	3.46	.989

Table B.17 Course Difficulty Expectation Results

			Type		
			C	T	R
I learn more through interacting with other students than working on my own	1 Disagree	N	31	26	57
		%	16.80%	9.00%	12.00%
	2	N	41	53	94
		%	22.20%	18.30%	19.80%
	3	N	52	80	132
		%	28.10%	27.70%	27.80%
	4	N	49	69	118
		%	26.50%	23.90%	24.90%
	5 Agree	N	12	61	73
		%	6.50%	21.10%	15.40%
	Total	Mean	2.84	3.3	3.19
		SD	1.18	1.24	1.24

Note: C= Control, T=Treatment, R=Total

Table B.18 Course Difficulty Results

			Type		
			C	T	R
How easy or difficult did you FIND this course to be?	1 Disagree	N	22	23	45
		%	11.90%	8.00%	9.50%
	2	N	39	48	87
		%	21.10%	16.60%	18.40%
	3	N	67	90	157
		%	36.20%	31.10%	33.10%
	4	N	41	67	108
		%	22.20%	23.20%	22.80%
	5 Agree	N	16	61	77
		%	8.60%	21.10%	16.20%
	Total	Mean	2.95	3.33	3.18
		SD	1.12	1.21	1.19

Note: C= Control, T=Treatment, R=Total

Table B.19 Course Grade Expectation Results

		Group Type					
		Control		Treatment		Total	
		Count	%	Count	%	Count	%
What grade do you expect to receive in this course?	A	90	48.6%	124	42.8%	214	45.1%
	A-	31	16.8%	30	10.3%	61	12.8%
	B	7	3.8%	31	10.7%	38	8.0%
	B-	7	3.8%	11	3.8%	18	3.8%
	B+	25	13.5%	28	9.7%	53	11.2%
	C	8	4.3%	15	5.2%	23	4.8%
	C-	3	1.6%	8	2.8%	11	2.3%
	C+	5	2.7%	29	10.0%	34	7.2%
	D	3	1.6%	3	1.0%	6	1.3%
	F	0	0.0%	1	0.3%	1	0.2%
	Prefer not to answer	6	3.2%	10	3.4%	16	3.4%

Table B.20 Perceived Learning Interaction Results Part 1

			Type		
			C	T	R
I learn more when I interact with other students, as opposed to listening to the instructor's lecturing	1 Disagree	N	14	15	29
		%	7.60%	5.20%	6.10%
	2	N	19	35	54
		%	10.30%	12.10%	11.40%
	3	N	50	84	134
		%	27.00%	29.10%	28.30%
	4	N	56	86	142
		%	30.30%	29.80%	30.00%
	5 Agree	N	46	69	115
		%	24.90%	23.90%	24.30%
	Total	Mean	3.55	3.55	3.55
		SD	1.19	1.13	1.15

Note: C= Control, T=Treatment, R=Total

Table B.21 Perceived Learning Interaction Results Part 2

			Type		
			C	T	R
I learn more through interacting with other students than working on my own	1 Disagree	N	14	15	29
		%	7.60%	5.20%	6.10%
	2	N	19	35	54
		%	10.30%	12.10%	11.40%
	3	N	50	84	134
		%	27.00%	29.10%	28.30%
	4	N	56	86	142
		%	30.30%	29.80%	30.00%
	5 Agree	N	46	69	115
		%	24.90%	23.90%	24.30%
	Total	Mean	3.55	3.55	3.55
		SD	1.19	1.13	1.15

Note: C= Control, T=Treatment, R=Total

Table B.22 Course Educational Value

			Type		
			C	T	R
What's your evaluation of the overall educational value of this course	1 Unsatisfactory	N	3	7	10
		%	1.60%	2.40%	2.10%
	2	N	4	15	19
		%	2.20%	5.20%	4.00%
	3	N	22	49	71
		%	11.90%	17.00%	15.00%
	4	N	65	84	149
		%	35.10%	29.10%	31.40%
	5 Satisfactory	N	91	134	225
		%	49.20%	46.40%	47.50%
	Total	Mean	4.28	4.12	4.18
		SD	0.88	1.02	0.91

Note: C= Control, T=Treatment, R=Total

Table B.23 Instructor Teaching Ability Result

			Type		
			C	T	R
What's your evaluation of the overall teaching ability of your instructor	1 Unsatisfactory	N	3	17	20
		%	1.60%	5.90%	4.20%
	2	N	6	26	32
		%	3.20%	9.00%	6.80%
	3	N	24	47	71
		%	13.00%	16.30%	15.00%
	4	N	51	76	127
		%	27.60%	26.30%	26.80%
	5 Satisfactory	N	101	123	224
		%	54.60%	42.60%	47.30%
	Total	Mean	4.3	3.91	4.06
		SD	0.93	1.21	1.12

Note: C= Control, T=Treatment, R=Total

Table B.24 Course Evaluation Results

			Type		
			C	T	R
Thinking about your own self-assessment of your work and assignments, what's your evaluation of this course	1 Unsatisfactory	N	1	4	5
		%	0.50%	1.40%	1.10%
	2	N	6	16	22
		%	3.20%	5.50%	4.60%
	3	N	36	57	93
		%	19.50%	19.70%	19.60%
	4	N	66	99	165
		%	35.70%	34.30%	34.80%
	5 Satisfactory	N	76	113	189
		%	41.10%	39.10%	39.90%
	Total	Mean	4.14	4.04	4.08
		SD	0.88	0.97	0.93

Note: C= Control, T=Treatment, R=Total

Table B.25 Critical Thinking Skills Results

			Type	
			C	T
During this course, my skill in critical thinking to solve problems has increased.	1 Disagree	N	6	6
		%	3.20%	2.10%
	2	N	8	16
		%	4.30%	5.50%
	3	N	22	55
		%	11.90%	19.00%
	4	N	82	106
		%	44.30%	36.70%
	5 Agree	N	67	106
		%	36.20%	36.70%
	Total	Mean	4.06	4
		SD	0.97	0.98

Note: C= Control, T=Treatment

Table B.26 Reading Comprehension Results

			Type	
			C	T
During this course, my ability to comprehend information has increased.	1 Disagree	N	5	5
		%	2.70%	1.70%
	2	N	5	13
		%	2.70%	4.50%
	3	N	28	52
		%	15.10%	18.00%
	4	N	81	113
		%	43.80%	39.10%
	5 Agree	N	66	106
		%	35.70%	36.70%
	Total	Mean	4.07	4.05
		SD	0.93	0.94

Note: C= Control, T=Treatment

Table B.27 Ability to Articulate Solutions Results

			Type	
			C	T
During this course, my ability to articulate and write a well thought out solution has increased	1 Disagree	N	5	9
		%	2.70%	3.10%
	2	N	9	15
		%	4.90%	5.20%
	3	N	24	64
		%	13.00%	22.10%
	4	N	76	115
		%	41.10%	39.80%
	5 Agree	N	71	86
		%	38.40%	29.80%
	Total	Mean	4.08	3.88
		SD	0.98	0.99

Note: C= Control, T=Treatment

Table B.28 Integrate Facts and Generalization Results

			Type	
			C	T
During this course, my ability to integrate facts and develop generalizations improved	1 Disagree	N	5	6
		%	2.70%	2.10%
	2	N	3	16
		%	1.60%	5.50%
	3	N	32	63
		%	17.30%	21.80%
	4	N	82	115
		%	44.30%	39.80%
	5 Agree	N	63	89
		%	34.10%	30.80%
	Total	Mean	4.05	3.92
		SD	0.91	0.96

Note: C= Control, T=Treatment

Table B.29 Stimulation to do Additional Reading Results

			Type	
			C	T
During this course, I was stimulated to do additional reading	1 Disagree	N	10	20
		%	5.40%	6.90%
	2	N	22	37
		%	11.90%	12.80%
	3	N	37	65
		%	20.00%	22.50%
	4	N	57	75
		%	30.80%	26.00%
	5 Agree	N	59	92
		%	31.90%	31.80%
	Total	Mean	3.72	3.63
		SD	1.19	1.24

Note: C= Control, T=Treatment

Table B.30 Value Other Points of View Results

			Type	
			C	T
During this course, I learned to value other points of view.	1 Disagree	N	7	18
		%	3.80%	6.20%
	2	N	9	26
		%	4.90%	9.00%
	3	N	26	61
		%	14.10%	21.10%
	4	N	71	77
		%	38.40%	26.60%
	5 Agree	N	72	107
		%	38.90%	37.00%
	Total	Mean	4.04	3.79
		SD	1.03	1.21

Note: C= Control, T=Treatment

Table B.31 Motivation Results Part 1

			Type	
			C	T
During this course, I was motivated to do my best work	1 Disagree	N	5	10
		%	2.70%	3.50%
	2	N	10	13
		%	5.40%	4.50%
	3	N	22	53
		%	11.90%	18.30%
	4	N	59	103
		%	31.90%	35.60%
	5 Agree	N	89	110
		%	48.10%	38.10%
	Total	Mean	4.17	4
		SD	1.02	1.03

Note: C= Control, T=Treatment

Table B.32 Motivation Results Part 2

			Type	
			C	T
Overall, I was motivated in this course	1 Disagree	N	5	17
		%	2.70%	5.90%
	2	N	12	25
		%	6.50%	8.70%
	3	N	27	57
		%	14.60%	19.70%
	4	N	69	95
		%	37.30%	32.90%
	5 Agree	N	72	95
		%	38.90%	32.90%
	Total	Mean	4.03	3.78
		SD	1.02	1.17

Note: C= Control, T=Treatment

Table B.33 Course Enjoyment Results Part 1

			Type	
			C	T
Overall, I enjoyed this course	1 Disagree	N	5	19
		%	2.70%	6.60%
	2	N	8	26
		%	4.30%	9.00%
	3	N	31	49
		%	16.80%	17.00%
	4	N	41	85
		%	22.20%	29.40%
	5 Agree	N	100	110
		%	54.10%	38.10%
	Total	Mean	4.21	3.83
		SD	1.04	1.22

Note: C= Control, T=Treatment

Table B.34 Course Enjoyment Results Part 2

			Type	
			C	T
Overall, I learned a lot in this course	1 Disagree	N	0	10
		%	0.00%	3.50%
	2	N	7	18
		%	3.80%	6.20%
	3	N	14	34
		%	7.60%	11.80%
	4	N	44	89
		%	23.80%	30.80%
	5 Agree	N	120	138
		%	64.90%	47.80%
	Total	Mean	4.5	4.13
		SD	0.8	1.07

Note: C= Control, T=Treatment

Table B.35 Inter-Construct Correlation

Inter-Construct Correlation (Fornell-Larcker criterion)										
			Inter-Construct Correlations							
Mean	SD	Construct	AL	AU	EE	FC	PE	PLe	PO	RU
60.59	40.8	AL	1							
1.68	0.95	AU	-0.14	1						
3.32	1.20	EE	-0.44	0.14	1					
3.93	0.79	FC	0.16	0.19	-0.24	0.78				
4.60	1.07	PE	0.08	0.15	-0.26	0.67	0.76			
4.81	1.02	PLe	0.22	0.06	-0.31	0.66	0.74	0.75		
76.57	31.6	PO	0.49	0.32	-0.35	0.29	0.20	0.23	1	
3.46	0.98	RU	0.02	0.12	-0.10	0.46	0.67	0.49	0.13	1

Construct Legend: Actual Learning (AL), Actual Use (AU), Effort Expectancy (EE), Facilitating Conditions (FC), Perceived Enjoyment (PE), Perceived Learning (PL), Performance Outcome (PO), Recommendation For Use (R)
According to Fornell-Larcker, for adequate discriminant validity, diagonal elements should be greater than corresponding off-diagonal. In the diagonal we present the square root of AVE. [92], [93]

Table B.36a PLS Factor Analysis Part 1

PLS Factor Analysis				
	Mean	Std. Deviation	Item Loading	Std. Error
Actual Learning				
CR = 1.00. AVE= 1.00				
Critical Thinking Question Score	60.599	40.80	1	0
Actual Use				
CR = 1.00. AVE= 1.00				
#Of Assignments Completed	1.79	0.97	1	0
Effort Expectancy				
CR = 1.00. AVE= 1.00				
How easy/difficult do you find this course is?	3.29	1.20	1	0
Facilitating Conditions				
CR = 0.821. AVE= 0.615				
The *problem & solution guidelines* given by the instructor are explicit enough.	3.99	0.97	0.77	0.03
I felt the grading process was fair.	3.94	0.94	0.73	0.04
The instructor coordinated the PL approach well.	3.86	1.11	0.85	0.02
Perceived Enjoyment				
CR = 0.869. AVE= 0.573				
I enjoyed the flexibility that the PL approach allowed in organizing my resources.	3.69	1.11	0.82	0.023
The time allowed for the PL assignments was sufficient.	3.85	1.16	0.65	0.05
During this course, I was motivated to do my best work	4.15	1.09	0.65	0.05
I enjoyed the PL approach.	3.49	1.20	0.85	0.02
System Usability Scale	59.56	19.88	0.79	0.03

CR = Composite Reliability; AVE: Average Variance Extracted, SD: Standard Deviation
Construct Scale: Actual learning (AL) and Performance Outcome (PO) are from 0 – 100; Actual Use (AU) is from 0 to 3; Effort Expectancy: (Easy) 1-5 (Difficult); CAP Cognitive and CAP affective is from 0 to 18; Facilitating Conditions, Perceived Enjoyment and Perceived Learning are from (Strongly Agree) 1 – 5 (Strongly Disagree).

‘**Table B.36b** PLS Factor Analysis Part 2

PLS Factor Analysis				
	Mean	Std. Deviation	Item Loading	Std. Error
Perceived Learning				
CR = 0.882. AVE= 0.556				
Overall, I learned a lot in this course.	4.13	1.07	0.80	0.03
I learned from having to make up problems.	3.84	1.02	0.78	0.03
I learned from solving problems with the PL approach.	3.64	1.06	0.77	0.03
I learned from grading other students' solutions.	3.67	1.221	0.71	0.03
CAP Cognitive	11.81	3.03	0.60	0.06
CAP Affective	12.13	3.878	0.81	0.03
Performance Outcome				
CR = 1.00. AVE= 1.00				
PL Score	76.5	31.6	1	0
Recommendation of Use				
CR = 1.00. AVE= 1.00				
Would you recommend in the future that the PL approach be used for this course an d its assignments?	3.46	0.991	1	0

CR = Composite Reliability; AVE: Average Variance Extracted, SD: Standard Deviation
Construct Scale: Actual learning (AL) and Performance Outcome (PO) are from 0 – 100; Actual Use (AU) is from 0 to 3; Effort Expectancy: (Easy) 1-5 (Difficult); CAP Cognitive and CAP affective is from 0 to 18; Facilitating Conditions, Perceived Enjoyment and Perceived Learning are from (Strongly Agree) 1 – 5 (Strongly Disagree).

Table B.37 Inter-Construct Statistics

	Original Sample (O) β	Sample Mean (M) β	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Actual Use -> Actual Learning (Critical thinking)	-0.146	-0.146	0.044	3.335	0.001
Effort Expectancy -> Perceived Enjoyment	-0.109	-0.109	0.049	2.245	0.025
Effort Expectancy -> Performance Outcome	-0.352	-0.352	0.051	6.855	0
Facilitating Conditions -> Perceived Enjoyment	0.649	0.652	0.038	17.274	0
Facilitating Conditions -> Perceived Learning	0.31	0.314	0.06	5.142	0
Moderating Effect 1 -> Actual Learning (Critical Thinking)	-0.158	-0.184	0.056	2.827	0.005
Perceived Enjoyment -> Perceived Learning	0.531	0.529	0.057	9.377	0
Perceived Enjoyment -> Recommendation For Use	0.684	0.685	0.055	12.393	0
Perceived Learning -> Actual Learning (Critical Thinking)	0.225	0.229	0.063	3.573	0
Perceived Learning -> Recommendation For Use	-0.014	-0.015	0.065	0.218	0.828
Performance Outcome -> Perceived Enjoyment	-0.026	-0.029	0.048	0.544	0.587

Table B.38 Course Grade, Critical Thinking Grade and Perceived Learning Results

	Type	N	Mean	Std. Deviation	Std. Error Mean
Course Grade	Treatment	207	74.06	24.82	1.73
	Control	144	86.23	15.02	1.25
Critical Question Grade	Treatment	207	60.60	40.90	2.84
	Control	144	80.24	31.22	2.60
CAP Cognitive	Treatment	289	11.81	3.03	.178
	Control	185	12.26	2.64	.194
CAP Affective	Treatment	289	12.13	3.88	.228
	Control	185	13.20	3.68	.271

Table B.39 Independent T-test for Course Grade, Critical Question, CAP Cognitive and CAP Affective measures

		Levene's Test for Eq. of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Std. Error Difference
Course Grade	Equal variances assumed	49.78	0	-5.25	349	0	2.32
	Equal variances not assumed			-5.71	343.02	0	2.13
Critical Question Grade	Equal variances assumed	53.65	0	-4.86	349	0	4.04
	Equal variances not assumed			-5.09	345.96	0	3.85
CAP Cognitive	Equal variances assumed	1.22	0.27	-1.64	472	0.101	0.27
	Equal variances not assumed			-1.69	429.75	0.091	0.26
CAP Affective	Equal variances assumed	0.18	0.67	-2.99	472	0.003	0.36
	Equal variances not assumed			-3.02	407.14	0.003	0.35

Table B.40 Course Grade, Critical Thinking Grade and Perceived Learning Results without Bravo Section

	Type	N	Mean	Std. Deviation	Std. Error Mean
Course Grade	Treatment	146	86.92	13.50264	1.12
	Control	144	86.23	15.02	1.25
Critical Question Grade	Treatment	146	78.52	33.28	2.75
	Control	144	80.24	31.22	2.60
CAP Cognitive	Treatment	228	12.07	3.03	.201
	Control	185	12.26	2.64	.194
CAP Affective	Treatment	228	12.62	3.70	.245
	Control	185	13.20	3.68	.271

Table B.41 Independent T-test for Course Grade, Critical Question, Cap Cognitive and Cap Affective measures without Bravo Section

		Levene's Test for Eq. of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Std. Error Difference
Course Grade	Equal variances assumed	1.78	0.18	0.41	288	0.683	1.68
	Equal variances not assumed			0.41	283.93	0.683	1.68
Critical Question Grade	Equal variances assumed	0.65	0.42	-0.45	288	0.651	3.79
	Equal variances not assumed			-0.45	287.28	0.651	3.79
CAP Cognitive	Equal variances assumed	0.96	0.33	-0.67	411	0.504	0.28
	Equal variances not assumed			-0.68	408.85	0.498	0.28
CAP Affective	Equal variances assumed	0.03	0.86	-1.58	411	0.115	0.37
	Equal variances not assumed			-1.58	394.51	0.115	0.37

Table B.42 Anonymized Descriptive Information for Pilot Study Student Interviewees

#ID	Sex	Age	Race/Ethnicity	Major	Year
1	Male	29	Latino/Hispanic	Civil Engineer	Senior
2	Female	20	Asian	Environmental Studies	Junior
3	Male	20	Caucasian (Polish)	Biomedical Engineer	Sophomore
4	Male	23	Egyptian/Arabic	Law Technology and Culture	Senior
5	Male	21	Asian	Computer Science	Junior
6	Male	20	Asian	Computer and Business	Junior
7	Male	20	Caucasian (White)	Computer Science	Junior
8	Male	22	Caucasian (White)	Compute Science	Junior
9	Male	20	African American	Computer Science	Sophomore
10	Male	21	South Asian	Computer Science	Junior
11	Male	20	Caucasian	Computer Science	Sophomore
12	Male	27	Asian	Computer Science	Senior
13	Male	25	Asian/Hindu	Computer Science	Senior

APPENDIX C

DISSERTATION STUDY RESULTS

Instruments used and tables generated for the Participatory Learning approach main dissertation survey.

C.1 Treatment – Regular Participatory Learning (PL) – Pre Survey

PL Survey
Participant Name:
Email address:

Participatory Learning

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)

1) I feel the grading process will be fair.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I feel under much pressure doing assignments this way.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) I feel I would rather use PL for assignments instead of the traditional approach.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

About the Course

1) For this course, I am motivated to do my best work.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

2) Overall, I expect to enjoy this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) Which gender do you identify yourself as.
    Male
    Female
    More than one, or Other
    Prefer not to answer

2) Is English your native or first language.

Yes

No

Prefer not to answer

3) Which categories describe you?

White (*For example: German, Irish, English, Italian, French, etc.)*

Hispanic, Latino or Spanish Origin *(For example: Mexican, Mexican-American, Puerto Rican, Cuban, Salvadorian, Dominican, Colombian, etc.)*

Black or African American *(For example: African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.)*

Asian *(For example: Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, etc.)*

American Indian or Alaska Native *(For example: Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Nome Eskimo Community, etc.)*

Middle Eastern or North African *(For example: Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian, etc.)*

Native Hawaiian or Other Pacific Islander *(For example: Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, etc.)*

Some other race, ethnicity, or origin. Please add it in the text field.

Prefer not to answer

4) What is your current year in the university?

Freshman

Sophomore

Junior

Senior

5) How old are you?

(Drop Drown Field from 18 to 90+)

6) How many courses have you taken that use Blackboard, Canvas, Moodle or a similar online support system, including this course?

None

1

2 – 4

5 or more

Prefer not to answer

7) How easy or difficult do you EXPECT this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

8) How easy or difficult do you FIND this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 – Difficult

9) What grade do you expect to receive in this course?

A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete

10) In my courses, when I learn new things, my understanding of them builds upon what I already know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

11) I learn more when I interact with other students, as opposed to listening to the instructor’s lecturing.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

12) What's your expectation of the overall educational value of this course?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

C.2 Treatment – Regular Participatory Learning (PL) - Mid-Survey

PL Survey
Participant Name:
Email address:

Participatory Learning (PL)

Participatory Learning structure

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)

1) I learn from having to make up problems.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I use real-world scenarios in designing and/or solving problems.
   Yes
   No
3) Using real-world scenarios increases my learning.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree ; Not Applicable (Answered No on previous question).
4) I learn from solving problems with the PL approach.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn from grading other students' solutions.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) I learn from reading other people's problems, solutions and comments on my grades.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) The PL approach enables me to demonstrate what I learned in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
8) I *don't* think students are able to design good problems for learning in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I feel the grading process is fair.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) The instructor coordinates the PL approach well.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I *don't think* students are capable of grading the solutions to the problems they designed.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) The *problem & solution guidelines* given by the instructor are explicit enough.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) The *grading criteria & guidelines* given by the instructor are explicit enough.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
14) The time allowed for the PL assignments is sufficient.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

15) The PL approach causes me to synthesize (connect or put together) different things I know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

16) I enjoy the flexibility that the PL approach allowed in organizing my resources.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

17) I feel under much pressure doing assignments this way.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

18) I would rather use PL for assignments instead of the traditional approach.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

19) I believe that the PL approach changes my relationship with my classmates from competitive to collaborative (working together).

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

20) I like that nobody knows who writes each task.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Participatory Learning (PL) Website Usability Survey (System Usability Scale)

In the following questions, whenever we refer to a "System" we refer to the PL Website.

21) I think that I would like to use this website frequently.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

22) I found the website unnecessarily complex.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

23) I thought the website was easy to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

24) I think that I would need the support of a technical person to be able to use this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

25) I found the various functions in this website were well integrated.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

26) I thought there was too much inconsistency in this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

27) I would imagine that most people would learn to use this website very quickly.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

28) I found the website very cumbersome to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

29) I felt very confident using the website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

30) I needed to learn a lot of things before I could get going with this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

31) The online PL Website makes the PL approach easy to do.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall Experience

32) Overall I feel the PL approach helps me learn more.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
33) I enjoy the PL approach.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
34) I would recommend in the future that the PL approach be used for this course and its assignments.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Tasks and Grading

35) The amount of work needed for completing a PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
36) The amount of time allocated for each PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
37) I like the way tasks are scheduled in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
38) I like the amount of tasks assigned in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
39) I am motivated to work on my assigned PL tasks.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
40) It would have been an improvement if the instructor had done all the grading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
41) Please add any other thoughts you have about the PL *approach* - thanks.
42) Please add any other thoughts you have about the PL *Website* - thanks!

About the Course

1) During this course, my skill in critical thinking has increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information has increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) During this course, my ability to articulate and write a well thought-out solution has increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
4) During this course, my ability to integrate facts and develop generalizations has improved.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) During this course, I am stimulated to do additional reading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) During this course, I learn to value other points of view.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

7) During this course, I am motivated to do my best work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I *cannot* produce a course study guide for future students.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) I have changed my attitudes about the course subject matter as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I can intelligently critique the texts used in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) I feel more self-reliant as a result of the content learned in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) I feel that I am a more sophisticated thinker as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I am motivated in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
15) Overall, I enjoy this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) Overall, I learn a lot in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
2) How easy or difficult did you FIND this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

3) What grade do you expect to receive in this course?

A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete

4) When I learn new things, my understanding of them builds upon what I already know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

6) What's your evaluation of the overall educational value of this course?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

7) What's your evaluation of the overall teaching ability of your instructor?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

8) Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

9) The amount of work assigned in this course is appropriate.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.3 Treatment – Regular Participatory Learning (PL) – Final Survey

PL Survey
Participant Name:
Email address:

Participatory Learning (PL)

Participatory Learning structure

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)
1) I learned from having to make up problems.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I used real-world scenarios in designing and/or solving problems.
    Yes
    No
3) Using real-world scenarios increased my learning.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree ; Not Applicable (Answered No on previous question).
4) I learned from solving problems with the PL approach.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learned from grading other students' solutions.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) I learned from reading other people's problems, solutions and comments on my grades.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) The PL approach enabled me to demonstrate what I learned in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
8) I *don't* think students were able to design good problems for learning in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I felt the grading process was fair.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

10) The instructor coordinated the PL approach well.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I *don't think* students were capable of grading the solutions to the problems they designed.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) The *problem & solution guidelines* given by the instructor were explicit enough.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) The *grading criteria & guidelines* given by the instructor were explicit enough.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
14) The time allowed for the PL assignments was sufficient.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

15) The PL approach caused me to synthesize (connect or put together) different things I knew.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

16) I enjoyed the flexibility that the PL approach allowed in organizing my resources.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

17) I felt under much pressure doing assignments this way.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

18) I would rather use PL for assignments instead of the traditional approach.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

19) I believe that the PL approach changed my relationship with my classmates from competitive to collaborative (working together).

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

20) I liked that nobody knew who wrote each task.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

PL Website Usability Survey (System Usability Scale)

In the following questions, whenever we refer to a "System" we refer to the PL Website.

21) I think that I would like to use this website frequently.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

22) I found the website unnecessarily complex.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

23) I thought the website was easy to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

24) I think that I would need the support of a technical person to be able to use this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

25) I found the various functions in this website were well integrated.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

26) I thought there was too much inconsistency in this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

27) I would imagine that most people would learn to use this website very quickly.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

28) I found the website very cumbersome to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

29) I felt very confident using the website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

30) I needed to learn a lot of things before I could get going with this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

31) The online PL Website made the PL approach easy to do.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall Experience

32) Overall I feel the PL approach helped me learn more.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
33) I enjoyed the PL approach.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
34) I would recommend in the future that the PL approach be used for this course and its assignments.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Tasks and Grading

35) The amount of work needed for completing a PL task was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
36) The amount of time allocated for each PL task was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
37) I liked the way tasks were scheduled in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
38) I liked the amount of tasks assigned in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
39) I was motivated to work on my assigned PL tasks.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
40) It would have been an improvement if the instructor had done all the grading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
41) For PL Assignment #1 (optionally include title), what grade did you get from the first grader.
42) For PL Assignment #1 (optionally include title), what grade did you get from the second grader.
43) For PL Assignment #1 (optionally include title), what was your final grade you received.
44) For PL Assignment #2 (optionally include title), what grade did you get from the first grader.
45) For PL Assignment #2 (optionally include title), what grade did you get from the second grader.
46) For PL Assignment #2 (optionally include title), what was your final grade you received.
47) For PL Assignment #3 (optionally include title), what grade did you get from the first grader.
48) For PL Assignment #3 (optionally include title), what grade did you get from the second grader.
49) For PL Assignment #3 (optionally include title), what was your final grade you received.
50) For PL Assignment #4 (optionally include title), what grade did you get from the first grader.
51) For PL Assignment #4 (optionally include title), what grade did you get from the second grader.

52) For PL Assignment #4 (optionally include title), what was your final grade you received.
53) For PL Assignment #5 (optionally include title), what grade did you get from the first grader.
54) For PL Assignment #5 (optionally include title), what grade did you get from the second grader.
55) For PL Assignment #5 (optionally include title), what was your final grade you received.
56) Please add any other thoughts you have about the PL *approach* - thanks.
57) Please add any other thoughts you have about the PL *Website* - thanks!

About the Course

1) During this course, my skill in critical thinking was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) During this course, my ability to articulate and write a well thought-out solution was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
4) During this course, my ability to integrate facts and develop generalizations improved.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) During this course, I was stimulated to do additional reading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) During this course, I learned to value other points of view.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) During this course, I was motivated to do my best work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I *cannot* produce a course study guide for future students.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) I have changed my attitudes about the course subject matter as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I can intelligently critique the texts used in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) I feel more self-reliant as a result of the content learned in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

13) I feel that I am a more sophisticated thinker as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I was motivated in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
15) Overall, I enjoyed this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) Overall, I learned a lot in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
2) How easy or difficult did you FIND this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
3) What grade do you expect to receive in this course?
A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete
4) When I learn new things, my understanding of them builds upon what I already know.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) What's your evaluation of the overall educational value of this course?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
7) What's your evaluation of the overall teaching ability of your instructor?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
8) Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
9) The amount of course work assigned in this course was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.4 Treatment – Microlearning Participatory Learning (PL) – Pre Survey

PL Survey
Participant Name:
Email address:

Participatory Learning

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)

1) I feel the grading process will be fair.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I feel under much pressure doing assignments this way.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) I feel I would rather use PL for assignments instead of the traditional approach.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

About the Course

1) For this course, I am motivated to do my best work.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

2) Overall, I expect to enjoy this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) Which gender do you identify yourself as.
    Male
    Female
    More than one, or Other
    Prefer not to answer
2) Is English your native or first language.
    Yes
    No
    Prefer not to answer

3) Which categories describe you?

White (*For example: German, Irish, English, Italian, French, etc.)*

Hispanic, Latino or Spanish Origin *(For example: Mexican, Mexican-American, Puerto Rican, Cuban, Salvadorian, Dominican, Colombian, etc.)*

Black or African American *(For example: African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.)*

Asian *(For example: Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, etc.)*

American Indian or Alaska Native *(For example: Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Nome Eskimo Community, etc.)*

Middle Eastern or North African *(For example: Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian, etc.)*

Native Hawaiian or Other Pacific Islander *(For example: Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, etc.)*

Some other race, ethnicity, or origin. Please add it in the text field.

Prefer not to answer

4) What is your current year in the university?

Freshman

Sophomore

Junior

Senior

5) How old are you?

(Drop Drown Field from 18 to 90+)

6) How many courses have you taken that use Blackboard, Canvas, Moodle or a similar online support system, including this course?

None

1

2 – 4

5 or more

Prefer not to answer

7) How easy or difficult do you EXPECT this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

8) How easy or difficult do you FIND this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

9) What grade do you expect to receive in this course?

A

A-

B+

B

B-

C+

C

C-

D

F

Incomplete

10) In my courses, when I learn new things, my understanding of them builds upon what I already know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

11) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

12) What's your expectation of the overall educational value of this course?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

C.5 Treatment – Microlearning Participatory Learning (PL)- Mid-Survey

PL Survey
Participant Name:
Email address:

Participatory Learning (PL)

Participatory Learning structure

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)

1) I learn from having to make up problems.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I use real-world scenarios in designing and/or solving problems.
   Yes
   No
3) Using real-world scenarios increase my learning.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree ; Not Applicable (Answered No on previous question).
4) I learn from solving problems with the PL approach.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn from grading other students' solutions.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) I learn from reading other people’s problems, solutions and comments on my grades.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) The PL approach enable me to demonstrate what I learned in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
8) I *don’t* think students are able to design good problems for learning in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I feel the grading process is fair.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) The instructor coordinates the PL approach well.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I *don’t think* students are capable of grading the solutions to the problems they designed.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) The *problem & solution guidelines* given by the instructor are explicit enough.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) The *grading criteria & guidelines* given by the instructor are explicit enough.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
14) The time allowed for the PL assignments is sufficient.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

15) The PL approach causes me to synthesize (connect or put together) different things I know.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) I enjoy the flexibility that the PL approach allowed in organizing my resources.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
17) I feel under much pressure doing assignments this way.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
18) I would rather use PL for assignments instead of the traditional approach.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
19) I believe that the PL approach changes my relationship with my classmates from competitive to collaborative (working together).
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
20) I like that nobody knows who writes each task.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Participatory Learning (PL) Website Usability Survey (System Usability Scale)

In the following questions, whenever we refer to a "System" we refer to the PL Website.

21) I think that I would like to use this website frequently.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
22) I found the website unnecessarily complex.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
23) I thought the website was easy to use.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
24) I think that I would need the support of a technical person to be able to use this website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
25) I found the various functions in this website were well integrated.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
26) I thought there was too much inconsistency in this website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
27) I would imagine that most people would learn to use this website very quickly.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
28) I found the website very cumbersome to use.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
29) I felt very confident using the website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
30) I needed to learn a lot of things before I could get going with this website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

31) The online PL Website makes the PL approach easy to do.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall Experience

32) Overall I feel the PL approach helps me learn more.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
33) I enjoy the PL approach.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
34) I would recommend in the future that the PL approach be used for this course and its assignments.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Tasks and Grading

35) The amount of work needed for completing a PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
36) The amount of time allocated for each PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
37) I like the way tasks are scheduled in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
38) I like the amount of tasks assigned in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
39) I am motivated to work on my assigned PL tasks.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
40) I enjoy that the PL stages (creating, solving, grading) are broken into multiple parts.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
41) I believe breaking down the PL stages into multiple parts is clearly explained
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree
42) Breaking down the PL stages into parts helps me have enough time to finish each task.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
43) It feels that breaking down the PL stages into parts adds unnecessary extra work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
44) It would have been an improvement if the instructor had done all the grading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
45) Please add any other thoughts you have about the PL *approach* - thanks.
46) Please add any other thoughts you have about the PL *Website* - thanks!

About the Course

1) During this course, my skill in critical thinking has increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information has increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

3) During this course, my ability to articulate and write a well thought-out solution has increased.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

4) During this course, my ability to integrate facts and develop generalizations has improved.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

5) During this course, I am stimulated to do additional reading.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

6) During this course, I learn to value other points of view.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

7) During this course, I am motivated to do my best work.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

9) I *cannot* produce a course study guide for future students.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

10) I have changed my attitudes about the course subject matter as a result of this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

11) I can intelligently critique the texts used in this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

12) I feel more self-reliant as a result of the content learned in this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

13) I feel that I am a more sophisticated thinker as a result of this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I am motivated in this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

15) Overall, I enjoy this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

16) Overall, I learn a lot in this course.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

2) How easy or difficult did you FIND this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

3) What grade do you expect to receive in this course?

A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete

4) When I learn new things, my understanding of them builds upon what I already know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

6) What's your evaluation of the overall educational value of this course?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

7) What's your evaluation of the overall teaching ability of your instructor?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

8) Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

9) The amount of work assigned in this course is appropriate.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.6 Treatment – Microlearning Participatory Learning (PL) – Final Survey

PL Survey
Participant Name:
Email address:

Participatory Learning (PL)

Participatory Learning structure

Think about the Participatory Learning (PL) approach to assignments (creating and solving problems, grading, disputing grades, etc.)

1) I learned from having to make up problems.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) I used real-world scenarios in designing and/or solving problems.
    Yes
    No
3) Using real-world scenarios increased my learning.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree; Not Applicable (Answered No on previous question).
4) I learned from solving problems with the PL approach.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learned from grading other students' solutions.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) I learned from reading other people's problems, solutions and comments on my grades.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) The PL approach enabled me to demonstrate what I learned in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
8) I *don't* think students were able to design good problems for learning in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I felt the grading process was fair.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) The instructor coordinated the PL approach well.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I *don't think* students were capable of grading the solutions to the problems they designed.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) The *problem & solution guidelines* given by the instructor were explicit enough.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) The *grading criteria & guidelines* given by the instructor were explicit enough.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
14) The time allowed for the PL assignments was sufficient.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

15) The PL approach caused me to synthesize (connect or put together) different things I knew.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

16) I enjoyed the flexibility that the PL approach allowed in organizing my resources.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

17) I felt under much pressure doing assignments this way.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

18) I would rather use PL for assignments instead of the traditional approach.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

19) I believe that the PL approach changed my relationship with my classmates from competitive to collaborative (working together).

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

20) I liked that nobody knew who wrote each task.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

PL Website Usability Survey (System Usability Scale)

In the following questions, whenever we refer to a "System" we refer to the PL Website.

21) I think that I would like to use this website frequently.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

22) I found the website unnecessarily complex.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

23) I thought the website was easy to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

24) I think that I would need the support of a technical person to be able to use this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

25) I found the various functions in this website were well integrated.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

26) I thought there was too much inconsistency in this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

27) I would imagine that most people would learn to use this website very quickly.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

28) I found the website very cumbersome to use.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

29) I felt very confident using the website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

30) I needed to learn a lot of things before I could get going with this website.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

31) The online PL Website made the PL approach easy to do.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall Experience

32) Overall I feel the PL approach helped me learn more.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
33) I enjoyed the PL approach.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
34) I would recommend in the future that the PL approach be used for this course and its assignments.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Tasks and Grading

35) The amount of work needed for completing a PL task was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
36) The amount of time allocated for each PL task was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
37) I liked the way tasks were scheduled in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
38) I liked the amount of tasks assigned in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
39) I was motivated to work on my assigned PL tasks.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
40) I enjoyed that the PL stages (creating, solving, grading) were broken into multiple parts.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
41) I believe breaking down the PL stages into multiple parts was clearly explained
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
42) Breaking down the PL stages into parts helped me have enough time to finish each task.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
43) It felt that breaking down the PL stages into parts added unnecessary extra work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
44) It would have been an improvement if the instructor had done all the grading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
45) For PL Assignment #1 (optionally include title), what grade did you get from the first grader.
46) For PL Assignment #1 (optionally include title), what grade did you get from the second grader.
47) For PL Assignment #1 (optionally include title), what was your final grade you received.
48) For PL Assignment #2 (optionally include title), what grade did you get from the first grader.
49) For PL Assignment #2 (optionally include title), what grade did you get from the second grader.

50) For PL Assignment #2 (optionally include title), what was your final grade you received.
51) For PL Assignment #3 (optionally include title), what grade did you get from the first grader.
52) For PL Assignment #3 (optionally include title), what grade did you get from the second grader.
53) For PL Assignment #3 (optionally include title), what was your final grade you received.
54) For PL Assignment #4 (optionally include title), what grade did you get from the first grader.
55) For PL Assignment #4 (optionally include title), what grade did you get from the second grader.
56) For PL Assignment #4 (optionally include title), what was your final grade you received.
57) For PL Assignment #5 (optionally include title), what grade did you get from the first grader.
58) For PL Assignment #5 (optionally include title), what grade did you get from the second grader.
59) For PL Assignment #5 (optionally include title), what was your final grade you received.
60) Please add any other thoughts you have about the PL *approach* - thanks.
61) Please add any other thoughts you have about the PL *Website* - thanks!

About the Course

1) During this course, my skill in critical thinking was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) During this course, my ability to articulate and write a well thought-out solution was increased.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
4) During this course, my ability to integrate facts and develop generalizations improved.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) During this course, I was stimulated to do additional reading.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) During this course, I learned to value other points of view.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) During this course, I was motivated to do my best work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I *cannot* produce a course study guide for future students.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) I have changed my attitudes about the course subject matter as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I can intelligently critique the texts used in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) I feel more self-reliant as a result of the content learned in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) I feel that I am a more sophisticated thinker as a result of this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I was motivated in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
15) Overall, I enjoyed this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) Overall, I learned a lot in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
2) How easy or difficult did you FIND this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
3) What grade do you expect to receive in this course?
A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete
4) When I learn new things, my understanding of them builds upon what I already know.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) What's your evaluation of the overall educational value of this course?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
7) What's your evaluation of the overall teaching ability of your instructor?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
8) Thinking about your own self-assessment of your w ork and assignments, what is your evaluation of this course.
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
9) The amount of course work assigned in this course was appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.7 Control – Pre Survey

Survey
Participant Name:
Email address:

About the Course

1) For this course, I am motivated to do my best work.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

2) Overall, I expect to enjoy this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) Which gender do you identify yourself as.
   Male
   Female
   More than one, or Other
   Prefer not to answer
2) Is English your native or first language.
   Yes
   No
   Prefer not to answer

3) Which categories describe you?

White (*For example: German, Irish, English, Italian, French, etc.)*
Hispanic, Latino or Spanish Origin *(For example: Mexican, Mexican-American, Puerto Rican, Cuban, Salvadorian, Dominican, Colombian, etc.)*
Black or African American *(For example: African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.)*
Asian *(For example: Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, etc.)*
American Indian or Alaska Native *(For example: Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Nome Eskimo Community, etc.)*
Middle Eastern or North African *(For example: Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian, etc.)*
Native Hawaiian or Other Pacific Islander *(For example: Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, etc.)*
Some other race, ethnicity, or origin. Please add it in the text field.
Prefer not to answer

4) What is your current year in the university?

Freshman
Sophomore
Junior
Senior

5) How old are you?

(Drop Drown Field from 18 to 90+)

6) How many courses have you taken that use Blackboard, Canvas, Moodle or a similar online support system, including this course?

None
1
2 – 4
5 or more
Prefer not to answer

7) How easy or difficult do you EXPECT this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

8) How easy or difficult do you FIND this course to be?

Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult

9) What grade do you expect to receive in this course?

A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete

10) In my courses, when I learn new things, my understanding of them builds upon what I already know.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

11) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.

Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

12) What's your expectation of the overall educational value of this course?

Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory

C.8 Control – Mid-Survey

Survey
Participant Name:
Email address:

About the Course

1) During this course, my skill in critical thinking has increased.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information has increased.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) During this course, my ability to articulate and write a well thought-out solution has increased.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
4) During this course, my ability to integrate facts and develop generalizations has improved.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) During this course, I am stimulated to do additional reading.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) During this course, I learn to value other points of view.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) During this course, I am motivated to do my best work.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I *cannot* produce a course study guide for future students.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) I have changed my attitudes about the course subject matter as a result of this course.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I can intelligently critique the texts used in this course.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) I feel more self-reliant as a result of the content learned in this course.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) I feel that I am a more sophisticated thinker as a result of this course.
 Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I am motivated in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
15) Overall, I enjoy this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) Overall, I learn a lot in this course.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
2) How easy or difficult did you FIND this course to be?
Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
3) What grade do you expect to receive in this course?
A
A-
B+
B
B-
C+
C
C-
D
F
Incomplete
4) When I learn new things, my understanding of them builds upon what I already know.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) What's your evaluation of the overall educational value of this course?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
7) What's your evaluation of the overall teaching ability of your instructor?
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
8) Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
9) The amount of work assigned in this course is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.9 Control – Final Survey

Survey
Participant Name:
Email address:

About the Course

1) During this course, my skill in critical thinking was increased.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
2) During this course, my ability to comprehend information was increased.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
3) During this course, my ability to articulate and write a well thought-out solution was increased.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
4) During this course, my ability to integrate facts and develop generalizations improved.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) During this course, I was stimulated to do additional reading.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) During this course, I learned to value other points of view.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
7) During this course, I was motivated to do my best work.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Perceived Learning Survey (CAP Perceived Learning Scale)

Please respond to each statement below as it specifically relates to your experience in this course.

8) I can organize course material into a logical structure.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
9) I *cannot* produce a course study guide for future students.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
10) I have changed my attitudes about the course subject matter as a result of this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
11) I can intelligently critique the texts used in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
12) I feel more self-reliant as a result of the content learned in this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
13) I feel that I am a more sophisticated thinker as a result of this course.
   Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Overall thoughts about this course

14) Overall, I was motivated in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
15) Overall, I enjoyed this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
16) Overall, I learned a lot in this course.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

Background Information

1) How easy or difficult did you EXPECT this course to be?
    Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
2) How easy or difficult did you FIND this course to be?
    Easy - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Difficult
3) What grade do you expect to receive in this course?
    A
    A-
    B+
    B
    B-
    C+
    C
    C-
    D
    F
    Incomplete
4) When I learn new things, my understanding of them builds upon what I already know.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
5) I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree
6) What's your evaluation of the overall educational value of this course?
    Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
7) What's your evaluation of the overall teaching ability of your instructor?
    Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
8) Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.
    Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
9) The amount of course work assigned in this course was appropriate.
    Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.10 Summary Changes to Survey from Pilot to Dissertation

<u>Overall:</u>
Split the survey from a final survey to three surveys during the semester (pre-, mid-, post-survey). Added a new treatment group with 4 additional questions. Added a few questions and minor changes to wording in existing questions.
a) Scales changed from 1-5 to 1-7
b) Whenever we referred to a "system" in previous surveys, we have changed it clarify that we referred to the "website" under development.
c) In the Pre, Mid and Post surveys, we changed the tense form of the verbs in some of the questions to better reflect the intention of the question in relation to when the survey is taking place during the semester.

The following questions/statements that are asked to students are in bold

<u>Survey section: About Participatory Learning</u>

Using real-world scenarios increases my learning.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree ; Not Applicable (Answered No on previous question).

I learn from reading other people's problems, solutions and comments on my grades.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

I would recommend in the future that the PL approach be used for this course and its assignments.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

The amount of work needed for completing a PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

The amount of time allocated for each PL task is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

I like the way tasks are scheduled in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

I like the amount of tasks assigned in the PL website.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

I am motivated to work on my assigned PL tasks.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

We also ask students to write out the grades given to them by other graders, the next three questions are repeated according to the amount of assignments given to the student as part of the PL study:

For PL Assignment #x (optionally include title), what grade did you get from the first grader.
For PL Assignment #x (optionally include title), what grade did you get from the second grader.
For PL Assignment #x (optionally include title), what was your final grade you received.

<u>The next four questions are asked specifically to a treatment section in the study:</u>

I enjoy that the PL stages (creating, solving, grading) are broken into multiple parts.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

I believe breaking down the PL stages into multiple parts is clearly explained
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - Strongly Agree

Breaking down the PL stages into parts helps me have enough time to finish each task.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

It feels that breaking down the PL stages into parts adds unnecessary extra work.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

<u>Survey Section: About Background Information</u>

Which categories describe you?
White (For example: German, Irish, English, Italian, French, etc.)
Hispanic, Latino or Spanish Origin (For example: Mexican, Mexican-American, Puerto Rican, Cuban, Salvadorian, Dominican, Colombian, etc.)
Black or African American (For example: African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.)
Asian (For example: Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, etc.)
American Indian or Alaska Native (For example: Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Nome Eskimo Community, etc.)
Middle Eastern or North African (For example: Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian, etc.)
Hawaiian or Other Pacific Islander (For example: Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, etc.)
Some other race, ethnicity, or origin. Please add it in the text field.
Prefer not to answer

What is your current year in the university?
Freshman
Sophomore
Junior
Senior

How old are you?
(Drop Down Field from 18 to 90+)

Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.
Highly Unsatisfactory - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Highly Satisfactory
The amount of work assigned in this course is appropriate.
Strongly Disagree - 1 - 2 - 3 - 4 - 5 - 6 - 7 - Strongly Agree

C.11 Survey Consent Form

Survey
[New Supplement: 06/09/2020]

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COVER PAGE and CONSENT FORM (to be detached)

Your consent is required to allow us to use your answers as data for our experiment. We will record that you have completed the survey, and then we will remove this cover page and the consent page so your answers are kept and used anonymously.

Note: you MUST enter the date, your name, email address and signature on the consent form on the next page for us to be allowed to use your survey answers.

For online surveys:
Note: you MUST enter your name and NJIT email address on the consent form on the next page for us to be allowed to use your survey answers.

Completing this survey is entirely optional and there will be no penalty for choosing not to fill it out!

Thanks!

--

We really appreciate taking the time to give us your feedback and reactions about the online CLASS System, which you have used in this course.

This survey will be kept confidential and your professor will not see your response.

New Jersey Institute of Technology
323 Martin Luther King Blvd.
Newark, NJ 07102

Consent to participate in a research study

Title of study: PL/CLASS Survey

COVER PAGE and CONSENT FORM

Your consent is required to allow us to use your answers as data for our survey. We will record that you have completed the survey, and then we will remove this cover page and the consent page so your answers are kept and used anonymously.

Note: you MUST enter your name and NJIT email address below for us to be allowed to use your survey answers.

Completing this survey is entirely optional and there will be no penalty for choosing not to fill it out!

Thanks!

We really appreciate taking the time to give us your feedback and reactions about the online PL System and approach, which you have used in this course.

This survey will be kept confidential and your professor will NOT see your response.

The survey is being conducted by Prof. Bieber at the New Jersey Institute of Technology, in agreement in your professor.

New Jersey Institute of Technology
323 Martin Luther King Blvd.
Newark, NJ 07102

Consent to participate in a research study

Title of study: PL Survey

Research study:
I have been asked to participate in a research study under the direction of Dr. Bieber. Other professional persons who work with him as study staff may assist.

Purpose:

The purpose of this survey is to find out my opinion of the PL System used in this course.

Duration:
My participation in this study is only filling out this survey, and should take about 40 minutes.

Procedures:
I have been told that for this study, I will complete the survey and this consent form. (As an alternative I can choose to do a 4-page essay on the main subject of this course.)

Participants:
I will be one of about 1600 participants in this study.

Exclusions:
I will inform the researcher if I do not wish to fill out the survey.
I will inform the researcher if I am under 18 (in which case I cannot participate).

Risks/discomforts:
I have been told that there are no known risks and/or discomforts to participating in the survey.

There also may be risks and discomforts that are not yet known. I fully recognize that there are risks that I may be exposed to by volunteering in this study which are inherent in participating in any study; I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

Online surveys are conducted on a secure (https) server. As an online participant, there is always the risk of intrusion by outside agents (i.e., hacking) and, therefore the possibility of being identified exists. We will make every reasonable effort to minimize this risk.

Confidentiality:
I must enter my actual name and college email address to get extra credit for this survey. I understand confidential is not the same as anonymous. Confidential means that my name will not be disclosed during the very short period before the consent form is separated from the survey form. Every effort will be made to maintain the confidentiality of my survey. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law.

Payment for participation:
I have been told that I will receive extra credit for my participation in this study.

Right to refuse or withdraw:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. I also understand that the investigator has the right to withdraw me from the study at any time.

Benefit for Society
The work derived from this research will help impact future education in general by providing a framework for collaborative learning at different levels including K-12, undergraduate and graduate levels. In addition, our educational framework and system that support it will be co-developed and piloted by a diverse group of students at NJIT so their valuable feedback will have strong impact in informing future design decisions. Finally, we will seek to make our educational system available to other educational institutions so a greater number of students and educators can benefit from it as well.

Individual to contact:
If I have any questions about my treatment or research procedures, I understand that I should contact the principal investigator at:

Prof. Bieber
Informatics Department, GITC 5100, NJIT, Newark NJ 07102-1982
(973) 596-3368 - bieber@njit.edu

If I have any addition questions about my rights as a research subject, I may contact:

Dr Horacio G. Rotstein, IRB Chair
New Jersey Institute Of Technology
323 Martin Luther King Boulevard
Newark, NJ 07102
(973) 596-5825
irb@njit.edu / horacio.g.rotstein@njit.edu

Consent of participant (Part 1)

By entering my name and email address, and clicking on the "Continue" button I am consenting to participate in this study.

NOTE: There is a 2nd consent form on the next page.

Consent of participant (Part 1)

I have read this entire form and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Participant name	______________________
NJIT/FDU email address	______________________
Signature	______________________
Date	______________________

For online surveys:

By entering my name and email address and clicking on the "Continue" button I am consenting to participate in this study.

Participant Name
Enter your full name here. It will be used together with your NJIT/FDU email address to give you extra credit. Your response won't be shared with the instructor.

Name ______________________

NJIT/FDU Email Address
Enter your NJIT/FDU student email here. It will be used together with your name to give you extra credit. Your response won't be shared with the instructor.

Email Address ______________________

Consent of participant (Part 2)

FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT WAIVER

NEW JERSEY INSTITUTE OF TECHNOLOGY
323 MARTIN LUTHER KING BLVD.
NEWARK, NJ 07102

AUTHORIZATION TO RELEASE INFORMATION

Student Consent for Educational Records to be Released to Researcher for Purposes of Analysis Only

Student's Name (please print): ______________________ NJIT UCID (e.g. rsb24) ______________________

PLEASE READ:
In accordance with the Family Educational Rights and Privacy Act of 1974 (FERPA), the undersigned student hereby permits New Jersey Institute of Technology to disclose the information specified below to the researcher, Dr. Michael Bieber, for the purposes of research only. This information will be kept strictly confidential and will not be disclosed to any third parties, nor will any identifiable information about the student be released.

This consent shall be valid only for the semester during which the student participates in the research study.

INFORMATION TO BE RELEASED:
The information to be obtained shall be limited to:

- The student's grade for the course assignments designated as part of this research
- The student's course grade for the course designated as part of this research
- Student interaction with the PL/CLASS system this semester as part of this research
- The student's overall GPA at the time of his or her participation in this research

I have read and understand the contents of this consent form pertaining to the Family Educational Rights and Privacy Act of 1974.

Student's Signature: Date:

____

For online surveys:

Enter your full name here to consent. Your response won't be shared with the instructor.

Participant Name

Name ____

NOTE 1:
The consent form will be the same for treatment and control sections. However, the following modification to the consent for participants in the control section on information to be released is made.

INFORMATION TO BE RELEASED:
The information to be obtained shall be limited to:

- The student's grade for the course assignments designated as part of this research
- The student's course grade for the course designated as part of this research
- The student's overall GPA at the time of his or her participation in this research

C.12 Interview Consent Form for Students

Interviews

COVER PAGE and CONSENT FORM

Your consent is required to allow us to use your comments in this interview for our experiment. Your comments are kept and used anonymously.

Note: you MUST enter the date, your name, email address and signature on the consent form on the next page for us to be allowed to use your comments.

If the interview is being conducted online, you must email your consent.

Participating in the interview is entirely voluntary
and there will be no penalty for choosing not to participate or to end the interview early.

Thanks!

We really appreciate taking the time to give us your feedback and reactions about the CLASS approach and web system, which you have used in this course.

(For students) This interview will be kept confidential and your professor will <u>not</u> see your comments, except in an anonymous set of excerpts from all interviews we conduct.

New Jersey Institute of Technology
323 Martin Luther King Blvd.
Newark, NJ 07102

Consent to participate in a research study

Title of study: PL/CLASS Interviews

Research study:
I,____, have been asked to participate in a research study under the direction of Dr. Bieber. Other professional persons who work with him as study staff may assist.

Purpose:
The purpose of this interview is to find out my opinion of the PL/CLASS System used in this course.

Duration:
My participation in this study is only participating in this interview, and should take about 20 minutes.

Procedures:
I have been told that for this study, I will complete this consent form and then talk with the researcher.

Participants:
I will be one of about 1600 participants in this total study.

Exclusions:
I will inform the researcher if I do not wish to participate in the interview.
I will inform the researcher if I am under 18 (in which case I cannot participate).

Risks/discomforts:
I have been told that there are no known risks and/or discomforts to participating in the interview.

There also may be risks and discomforts that are not yet known. I fully recognize that there are risks that I may be exposed to by volunteering in this study which are inherent in participating in any study; I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

I understand that the audio of this interview will be recorded.

Recordings held online will be kept on a secure (https) server without the participant's name associated. As an online participant, there is always the risk of intrusion by outside agents (i.e., hacking) and, therefore the possibility of exposing the recording exists. We will make every reasonable effort to minimize this risk.

Confidentiality:
I must enter my actual name and email address. I understand confidential is not the same as anonymous. Confidential means that my name will not be disclosed as participating. Every effort will be made to maintain the confidentiality of my comments. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law.

Payment for participation:
I will receive extra credit for agreeing to participate in this study.

Right to refuse or withdraw:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. I also understand that the investigator has the right to withdraw me from the study at any time.

Individual to contact:
If I have any questions about my treatment or research procedures, I understand that I should contact the principal investigator at:

Prof. Michael Bieber
IS Department, GITC 5100, NJIT
(973) 596-3368 - bieber@njit.edu

If I have any addition questions about my rights as a research subject, I may contact:

Dr Horacio G. Rotstein, IRB Chair
New Jersey Institute Of Technology
323 Martin Luther King Boulevard
Newark, NJ 07102
(973) 596-5825
irb@njit.edu / horacio.g.rotstein@njit.edu

Consent of participant

I have read this entire form and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Participant name	____________________
Email address	____________________
Signature	____________________
Date	____________________

C.13 Interview Consent Form for Professors

Interviews

COVER PAGE and CONSENT FORM

Your consent is required to allow us to use your comments in this interview for our experiment. Your comments are kept and used anonymously.

Note: you MUST enter the date, your name, email address and signature on the consent form on the next page for us to be allowed to use your comments.

If the interview is being conducted online, you must email your consent.

Participating in the interview is entirely voluntary
and there will be no penalty for choosing not to participate or to end the interview early.

Thanks!

We really appreciate taking the time to give us your feedback and reactions about the CLASS approach and web system, which you have used in this course.

(For students) This interview will be kept confidential and your professor will not see your comments, except in an anonymous set of excerpts from all interviews we conduct.

New Jersey Institute of Technology
323 Martin Luther King Blvd.
Newark, NJ 07102

Consent to participate in a research study

Title of study: PL/CLASS Interviews

Research study:
I,____, have been asked to participate in a research study under the direction of Dr. Bieber. Other professional persons who work with him as study staff may assist.

Purpose:
The purpose of this interview is to find out my opinion of the PL/CLASS System used in this course.

Duration:
My participation in this study is only participating in this interview, and should take about 20 minutes.

Procedures:
I have been told that for this study, I will complete this consent form and then talk with the researcher.

Participants:
I will be one of about 1600 participants in this total study.

Exclusions:
I will inform the researcher if I do not wish to participate in the interview.
I will inform the researcher if I am under 18 (in which case I cannot participate).

Risks/discomforts:
I have been told that there are no known risks and/or discomforts to participating in the interview.

There also may be risks and discomforts that are not yet known. I fully recognize that there are risks that I may be exposed to by volunteering in this study which are inherent in participating in any study; I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

I understand that the audio of this interview will be recorded.

Recordings held online will be kept on a secure (https) server without the participant's name associated. As an online participant, there is always the risk of intrusion by outside agents (i.e., hacking) and, therefore the possibility of exposing the recording exists. We will make every reasonable effort to minimize this risk.

Confidentiality:
I must enter my actual name and email address. I understand confidential is not the same as anonymous. Confidential means that my name will not be disclosed as participating. Every effort will be made to maintain the confidentiality of my comments. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law.

Right to refuse or withdraw:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. I also understand that the investigator has the right to withdraw me from the study at any time.

Individual to contact:
If I have any questions about my treatment or research procedures, I understand that I should contact the principal investigator at:

Prof. Michael Bieber
IS Department, GITC 5100, NJIT
(973) 596-3368 - bieber@njit.edu

If I have any addition questions about my rights as a research subject, I may contact:

Dr Horacio G. Rotstein, IRB Chair
New Jersey Institute Of Technology
323 Martin Luther King Boulevard
Newark, NJ 07102
(973) 596-5825
irb@njit.edu / horacio.g.rotstein@njit.edu

Consent of participant

I have read this entire form and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Participant name ______________________

Email address ______________________

Signature ______________________

Date ______________________

C.14 Interview Questions (Student)

Hello, thank you very much for coming, my name is Erick and I work with Professors Michael Bieber and Roxanne Hiltz on the Participatory Learning (PL) Approach, also known as CLASS.

Today we will talk about your experiences with the PL approach and also talk about the website. There is not a right or wrong answer as we are hoping to get a broad array of perspectives. We will begin with some background questions and then we will go in more depth about your experiences this semester. If you have any questions before we begin please let me know. If you feel like you don't want to answer a question we can just skip over it. You should now that the answers will not be shared with your Professor. Before we continue I would like you to agree to verify you have agreed, signed and emailed back the consent form sent in advance before this interview.

Professor Name:

Student Name:

Major:

Year of Study (I.e. Freshman):

Age:

Sex:

Race/Ethnicity:

1. Let's continue with some background questions. Can you describe to me a typical college day for you?
2. Could you walk me through a typical classroom period in (Professor Name) class? Did he or she do anything special before giving you a PL assignment or task?
3. Overall, how would you describe your experience with the PL approach? (The overall process or creating your own questions, solutions, and grading each other, not the website)
4. Could you walk me through a typical PL assignment you did?
5. In general, was there anything you liked about the PL process? Could you explain why?
6. Besides the website, in general, was there anything you did not like about the PL process? Could you explain why?
7. Could you talk to me about your experiences when creating a problem. Was there anything you particularly liked or disliked?
8. Could you talk to me about your experiences when solving someone else's problem. Was there anything you particularly liked or disliked?
9. Could you talk to me about your experiences when grading others? Was there anything you particularly liked or disliked? Why? Could you talk to me about your experiences when being graded by others? Was there anything you particularly liked or disliked? Why?
10. PL has several ways for you to view the work that other students have done. Did you get to read your fellow students' problems, solutions or their grades? Did you find this interesting or useful? Why?
11. Was there anything you liked or disliked about the length of the PL assignments? Explain

12. Was there anything you liked or disliked about how the PL assignments were scheduled? Explain
13. About the PL website, was there anything you liked about it?
14. Was there anything you disliked about it? (the PL website) Such as things that didn't work as intended?

We are about to finish; we have a couple of questions more

15. Would you recommend this course to continue using the PL approach in the future? Why or why not? Also assuming it continues to use PL, would you recommend this course to someone else?
16. Reflecting on your experience with PLA, would you say this approach helped you learn more, less or had no impact on your learning? Why?
17. (If the student has used the PL more than one semester) Now that you have used the PL system for two semesters or more, is there anything different you have noticed, or have your thoughts changed about it?
18. Is there any other question we should have asked or any comment you would like to make?

C.15 Interview Questions (Professor)

Hello Professor [Name], thank you very much for your help and support this past semester with our Participatory Learning (PL) study.
Today we will have a conversation about your experiences (throughout the semester) when trying out the PL approach for your assignments and trying out our newly developed website. We would talk about what you think went well, and also what you think didn't go so well.
Let's begin with some background questions.

1. Could you please tell me a little bit more about the course you taught this semester where we tried out the PL approach? For example: is this course primarily recitation-based or practical, is this face-to-face or distant learning. How many students you had, different sections, etc.
2. Could you describe the activities you did during a classroom period? Was there anything in particular you did before giving students a PL assignment? (If the Professor has used PL more than once, ask the following) When compared to the previous semester, was there any noticeable difference in the activities you did?

Now, first. let's talk about the PL approach (not the website). The PL approach refers to the process of students creating problems, solutions and grading each other.

3. In general, thinking about the process (not the website), what do you think went well this semester? (If the Professor has used PL more than once, ask the following) Do you think this is better or the same when compared to last semester?
4. In contrast, thinking about the process, what do you think did not go well with the PL process this semester? (If the Professor has used PL more than once, ask the following) Do you think this is worse or the same when compared to last semester?
5. About this semester, do you believe the students found value in the process? Was there any comments or feedback given to you by students about it?
6. Did you notice any difference in your students' behavior (i.e. enthusiasm) or class participation between sections that used PL and sections that did not? (If the Professor has used PL more than once, ask the following) Were there any differences between class and classes from previous that had PL?
    - 6.1 (If the Professor has used PL more than once, ask the following) Some of your students may have participated in the PL study the previous semester, did you notice any difference or received any comments from them?

Now let's talk about more specifics aspects of the process.

7. When students were creating their own problems, was there anything you particularly liked about this step? Was there anything you particularly disliked or think could be further improved?
8. When you had the opportunity to ask students to revise their problem, was there anything you particularly liked about reviewing the students' work and the

revision process before it went to another student? Was there anything you didn't particularly like or think could be further improved?

9. When students were solving other students' problems, was there anything you particularly liked, disliked or think could be further improved?
10. When students were grading each other, was there anything you particularly liked, disliked or think could be improved? Could we change anything for students to learn more from grading?

Now let's talk about how your students reacted to the PL approach.

11. Were there any steps in the process where you felt the students struggled with? Why did you think this happened? What could we do to improve this aspect? [For each of the parts described]
12. Were there any steps you think that went well with students this semester?

Now let's talk about the website, not the process.

13. What was your overall thoughts about the website this semester? We are constantly updating the site so there might have been features this semester that were not previously available.
14. Was there any particular aspect of the website that you would like to be further improved?
15. Was there any particular aspect of the website that went well?

We are about to end the debrief session

16. Overall, would you use PL again, and would you recommend it to other faculty for this or other courses, either enthusiastically or reluctantly? If not, what would need to be improved, if anything, for you to use it again?
17. What other assignments besides the ethical scenario do you think could benefit from PL?

Before we finish, was there any particular question you felt we should have asked you or do you have anything else you would like to share with us?
Thank you for your time.

Table C.16 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 1

Question	N	Mean	Med	SD	Skew	Kurt
The "problem & solution guidelines" given by the instructor were explicit enough.	296	5.29	5.00	1.458	-0.733	0.086
The "grading criteria & guidelines" given by the instructor were explicit enough.	296	5.33	6.00	1.520	-0.783	0.015
The time allowed for the PL assignments was sufficient.	296	5.31	6.00	1.665	-0.854	-0.076
The PL approach caused me to synthesize (connect or put together	296	4.87	5.00	1.566	-0.547	-0.208
I enjoyed the flexibility that the PL approach allowed in organizing my resources.	296	4.76	5.00	1.633	-0.431	-0.455
I felt under much pressure doing assignments this way.	296	3.91	4.00	1.762	0.075	-0.926
I would rather use PL for assignments instead of the traditional approach.	296	3.82	4.00	1.835	0.068	-0.875
I believe that the PL approach changed my relationship with my classmates from competitive to collaborative (working together	296	3.93	4.00	1.780	-0.141	-0.839
I liked that nobody knew who wrote each task.	296	5.38	6.00	1.650	-0.802	-0.157
The online PL Website made the PL approach easy to do.	296	4.55	5.00	1.602	-0.341	-0.397

Table C.17 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 2

Question	N	Mean	Med	SD	Skew	Kurt
The "problem & solution guidelines" given by the instructor were explicit enough.	296	5.29	5.00	1.458	-0.733	0.086
The "grading criteria & guidelines" given by the instructor were explicit enough.	296	5.33	6.00	1.520	-0.783	0.015
The time allowed for the PL assignments was sufficient.	296	5.31	6.00	1.665	-0.854	-0.076
The PL approach caused me to synthesize (connect or put together	296	4.87	5.00	1.566	-0.547	-0.208
I enjoyed the flexibility that the PL approach allowed in organizing my resources.	296	4.76	5.00	1.633	-0.431	-0.455
I felt under much pressure doing assignments this way.	296	3.91	4.00	1.762	0.075	-0.926
I would rather use PL for assignments instead of the traditional approach.	296	3.82	4.00	1.835	0.068	-0.875
I believe that the PL approach changed my relationship with my classmates from competitive to collaborative (working together	296	3.93	4.00	1.780	-0.141	-0.839
I liked that nobody knew who wrote each task.	296	5.38	6.00	1.650	-0.802	-0.157
The online PL Website made the PL approach easy to do.	296	4.55	5.00	1.602	-0.341	-0.397
Overall I feel the PL approach helped me learn more.	296	4.40	4.00	1.704	-0.314	-0.655

Table C.18 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 3

Question	N	Mean	Med	SD	Skewness	Kurtosis
I enjoyed the PL approach.	296	4.32	4.00	1.825	-0.256	-0.843
I would recommend in the future that the PL approach be used for this course and its assignments.	296	4.21	4.00	1.825	-0.207	-0.915
The amount of work needed for completing a PL task was appropriate.	296	5.00	5.00	1.483	-0.659	0.035
The amount of time allocated for each PL task was appropriate.	296	5.11	5.00	1.654	-0.835	0.022
I liked the way tasks were scheduled in the PL website.	296	4.75	5.00	1.746	-0.533	-0.614
I liked the amount of tasks assigned in the PL website.	296	4.77	5.00	1.588	-0.492	-0.185
I was motivated to work on my assigned PL tasks.	296	4.45	4.00	1.754	-0.264	-0.750
It would have been an improvement if the instructor had done all the grading.	296	4.42	4.00	1.582	-0.080	-0.462
During this course, my skill in critical thinking was increased.	506	5.13	5.00	1.460	-0.837	0.396
During this course, my ability to comprehend information was increased.	506	5.07	5.00	1.487	-0.758	0.188
During this course, my ability to articulate and write a well thought-out solution was increased.	506	5.12	5.00	1.521	-0.761	0.218

Table C.19 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 4

Question	N	Mean	Med	SD	Skew	Kurt
During this course, my ability to integrate facts and develop generalizations improved.	506	5.05	5.00	1.486	-0.677	0.118
During this course, I was stimulated to do additional reading.	506	4.50	5.00	1.721	-0.307	-0.696
During this course, I learned to value other points of view.	506	5.02	5.00	1.600	-0.606	-0.235
During this course, I was motivated to do my best work.	506	5.22	6.00	1.621	-0.805	-0.054
I can organize course material into a logical structure.	506	5.20	5.00	1.484	-0.784	0.365
I "cannot" produce a course study guide for future students.	506	3.99	4.00	1.763	0.200	-0.897
I have changed my attitudes about the course subject matter as a result of this course.	506	4.73	5.00	1.451	-0.332	-0.079
I can intelligently critique the texts used in this course.	506	4.69	5.00	1.559	-0.467	-0.216
I feel more self-reliant as a result of the content learned in this course.	506	4.92	5.00	1.548	-0.597	-0.125
I feel that I am a more sophisticated thinker as a result of this course.	506	4.87	5.00	1.601	-0.652	-0.122
Overall, I was motivated in this course.	506	5.03	5.00	1.728	-0.789	-0.221
Overall, I enjoyed this course.	506	5.14	6.00	1.757	-0.883	-0.070

Table C.20 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 5

Question	N	Mean	Med	SD	Skew	Kurt
Overall, I learned a lot in this course.	506	5.40	6.00	1.556	-1.002	0.510
How easy or difficult did you EXPECT this course to be	506	4.42	4.00	1.536	-0.170	-0.513
How easy or difficult did you FIND this course to be?	506	4.63	5.00	1.511	-0.186	-0.605
When I learn new things, my understanding of them builds upon what I already know.	506	5.55	6.00	1.212	-0.608	0.114
I learn more when I interact with other students, as opposed to listening to the instructor's lecturing.	506	4.81	5.00	1.551	-0.445	-0.311
What's your evaluation of the overall educational value of this course?	280	5.00	5.00	1.465	-0.689	0.116
What's your evaluation of the overall teaching ability of your instructor?	280	5.14	6.00	1.690	-0.686	-0.468
Thinking about your own self-assessment of your work and assignments, what is your evaluation of this course.	280	4.84	5.00	1.489	-0.516	-0.225
The amount of work assigned in this course was appropriate.	506	5.51	6.00	1.396	-0.864	0.341

Table C.21 Descriptive Statistics, Mean, Median, SD, Skewness and Kurtosis Part 6

Question	N	Mean	Med	SD	Skew	Kurt
I enjoyed that the PL stages (creating, solving, grading) were broken into multiple parts.	25	5.68	6	1.28	-1.02	1.2
I believe breaking down the PL stages into multiple parts was clearly explained.	25	4.96	5	1.4	-0.92	0.47
Breaking down the PL stages into parts helps me have enough time to finish each task.	25	5.32	5	1.28	-0.4	-0.69
It felt that breaking down the PL stages into parts added unnecessary extra work.	25	3.52	3	1.53	0	-0.78
Survey 3 CAP Affective	506	11.51	12.00	3.961	-0.565	0.211
Survey 3 CAP Cognitive Score	506	10.91	11.00	3.522	-0.467	0.369
PL FINAL GRADE	259	80.13	96.00	29.07	-1.424	0.764
Survey 3 Usability Score	296	54.86	52.50	21.04	-0.095	-0.110
GPA	442	3.125	3.5000	1.111	-2.024	3.110

Table C.22 Enjoyed the PL Approach

	I enjoyed the PL approach.							
	1	2	3	4	5	6	7	Total
N	28	22	33	57	54	38	39	271
%	10.3	8.1	12.2	21.0	19.9	14.0	14.4	
Mean								4.3
Median								4
Mode								4
SD								1.8

Likert Scale: 1 – Disagree, 7-Aagree

Table C.23 Liked the Amount of Tasks Assigned in the PL Website

	I liked the amount of tasks assigned in the PL website.							
	1	2	3	4	5	6	7	Total
N	14	9	25	63	68	45	47	271
%	5.2	3.3	9.2	23.2	25.1	16.6	17.3	
Mean								4.8
Median								5
Mode								5
SD								1.6

Table C.24 Was Motivated to Work on my Assigned PL Tasks

	I was motivated to work on my assigned PL tasks.							
	1	2	3	4	5	6	7	Total
N	21	21	32	64	53	36	44	271
%	7.7	7.7	11.8	23.6	19.6	13.3	16.2	
Mean								4.4
Median								4
Mode								4
SD								1.8

Table C.25 Enjoyed the PL Approach by Professor and Course

		PROFESSOR							
		PC	PD		PE	PH	PS	PI	PT
		HUM 3	HUM 1	HUM 4	STEM 4	HUM 2	STEM 2	STEM 3	STEM 1
1	N	1	2	2	9	1	3	5	5
	%	2.7	18.2	7.7	28.1	2.9	10.3	17.2	6.9
2	N	3	0	2	1	3	5	3	5
	%	8.1	.0	7.7	3.1	8.6	17.2	10.3	6.9
3	N	3	3	1	3	6	2	4	11
	%	8.1	27.3	3.8	9.4	17.1	6.9	13.8	15.3
4	N	4	1	7	8	12	5	8	12
	%	10.8	9.1	26.9	25.0	34.3	17.2	27.6	16.7
5	N	6	2	7	5	9	7	2	16
	%	16.2	18.2	26.9	15.6	25.7	24.1	6.9	22.2
6	N	6	2	2	5	2	1	7	13
	%	16.2	18.2	7.7	15.6	5.7	3.4	24.1	18.1
7	N	14	1	5	1	2	6	0	10
	%	37.8	9.1	19.2	3.1	5.7	20.7	.0	13.9
T	N	37	11	26	32	35	29	29	72
	Mn	5.3	4.0	4.6	3.6	4.1	4.2	3.7	4.5
	Md	6	4	5	4	4	4	4	5
	Mo	7	3	4[a]	1	4	5	4	5
	SD	1.8	2.0	1.8	1.9	1.3	2.0	1.8	1.7

Liker Scale 1:Disagree, 7-Agree
Mn: mean, Md: median, Mo: mode

Table C.26 Chi-Squared Test for Table C.25

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	72.966[a]	42	.002
Likelihood Ratio	75.334	42	.001
Linear-by-Linear Association	11.322	1	.001
N of Valid Cases	271		

Table C.27 ANOVA for Table C.25

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	72.249	7	10.321	3.269	.002
Within Groups	830.459	263	3.158		
Total	902.708	270			

Table C.28 Homogeneity of Variance for Table C-27

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I enjoyed the PL approach.	Based on Mean	1.548	7	263	.151
	Based on Median	1.125	7	263	.348
	Based on Median and with adjusted df	1.125	7	255.943	.348
	Based on trimmed mean	1.549	7	263	.151

Table C.29a Tukey Test for Table C.27 Part 1

Multiple Comparisons						
Dependent Variable: I enjoyed the PL approach.						
Tukey HSD						
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
STEM 3	STEM 4	0.127	0.456	1	-1.26	1.52
	STEM 1	-0.81	0.391	0.435	-2	0.38
	HUM 1	-0.31	0.629	1	-2.23	1.61
	HUM 2	-0.425	0.446	0.98	-1.79	0.94
	HUM 4	-0.887	0.48	0.587	-2.35	0.58
	STEM 2	-0.517	0.467	0.955	-1.94	0.91
	HUM 3	-1.608*	0.441	0.008	-2.95	-0.26
STEM 4	STEM 3	-0.127	0.456	1	-1.52	1.26
	STEM 1	-0.937	0.378	0.207	-2.09	0.22
	HUM 1	-0.437	0.621	0.997	-2.34	1.46
	HUM 2	-0.552	0.435	0.909	-1.88	0.78
	HUM 4	-1.014	0.469	0.378	-2.45	0.42
	STEM 2	-0.644	0.456	0.85	-2.04	0.75
	HUM 3	-1.735*	0.429	0.002	-3.05	-0.42
STEM 1	STEM 3	0.81	0.391	0.435	-0.38	2
	STEM 4	0.938	0.378	0.207	-0.22	2.09
	HUM 1	0.5	0.575	0.988	-1.26	2.26
	HUM 2	0.386	0.366	0.966	-0.73	1.5
	HUM 4	-0.077	0.407	1	-1.32	1.17
	STEM 2	0.293	0.391	0.995	-0.9	1.49
	HUM 3	-0.797	0.359	0.344	-1.9	0.3
HUM 1	STEM 3	0.31	0.629	1	-1.61	2.23
	STEM 4	0.438	0.621	0.997	-1.46	2.34
	STEM 1	-0.5	0.575	0.988	-2.26	1.26
	HUM 2	-0.114	0.614	1	-1.99	1.76
	HUM 4	-0.577	0.639	0.986	-2.53	1.38
	STEM 2	-0.207	0.629	1	-2.13	1.72
	HUM 3	-1.297	0.61	0.401	-3.16	0.57

Table C.29b Tukey Test for Table C.27 Part 2

Multiple Comparisons						
Dependent Variable: I enjoyed the PL approach.						
Tukey HSD						
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
HUM 2	STEM 3	0.425	0.446	0.98	-0.94	1.79
	STEM 4	0.552	0.435	0.909	-0.78	1.88
	STEM 1	-0.386	0.366	0.966	-1.5	0.73
	HUM 1	0.114	0.614	1	-1.76	1.99
	HUM 4	-0.463	0.46	0.973	-1.87	0.94
	STEM 2	-0.093	0.446	1	-1.46	1.27
	HUM 3	-1.183	0.419	0.094	-2.46	0.1
HUM 4	STEM 3	0.887	0.48	0.587	-0.58	2.35
	STEM 4	1.014	0.469	0.378	-0.42	2.45
	STEM 1	0.077	0.407	1	-1.17	1.32
	HUM 1	0.577	0.639	0.986	-1.38	2.53
	HUM 2	0.463	0.46	0.973	-0.94	1.87
	STEM 2	0.37	0.48	0.994	-1.1	1.84
	HUM 3	-0.72	0.455	0.759	-2.11	0.67
STEM 2	STEM 3	0.517	0.467	0.955	-0.91	1.94
	STEM 4	0.644	0.456	0.85	-0.75	2.04
	STEM 1	-0.293	0.391	0.995	-1.49	0.9
	HUM 1	0.207	0.629	1	-1.72	2.13
	HUM 2	0.093	0.446	1	-1.27	1.46
	HUM 4	-0.37	0.48	0.994	-1.84	1.1
	HUM 3	-1.09	0.441	0.211	-2.44	0.26
HUM 3	STEM 3	1.608*	0.441	0.008	0.26	2.95
	STEM 4	1.735*	0.429	0.002	0.42	3.05
	STEM 1	0.797	0.359	0.344	-0.3	1.9
	HUM 1	1.297	0.61	0.401	-0.57	3.16
	HUM 2	1.183	0.419	0.094	-0.1	2.46
	HUM 4	0.72	0.455	0.759	-0.67	2.11
	STEM 2	1.09	0.441	0.211	-0.26	2.44

Table C.30 Enjoyed the PL Approach by GPA Level

		GPA LEVEL			
		Missing	Low	Med	High
1	N	2	1	3	5
	%	11.1	5.0	2.8	4.0
2	N	1	1	5	5
	%	5.6	5.0	4.7	4.0
3	N	1	1	3	6
	%	5.6	5.0	2.8	4.8
4	N	4	2	12	19
	%	22.2	10.0	11.2	15.1
5	N	6	5	19	27
	%	33.3	25.0	17.8	21.4
6	N	1	3	36	30
	%	5.6	15.0	33.6	23.8
7	N	3	7	29	34
	%	16.7	35.0	27.1	27.0
Total	Count	18	20	107	126
	Mean	4.4	5.3	5.5	5.3
	Median	5	6	6	6
	Mode	5	7	6	7
	SD	1.8	1.8	1.5	1.6

Table C.31 Chi-Squared Test for Table C.30

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	21.755
df	18
Sig.	.243[a]

Table C.32 ANOVA for C.30

ANOVA					
I enjoyed the PL approach.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.363	3	1.788	.532	.661
Within Groups	897.345	267	3.361		
Total	902.708	270			

Table C.33 Homogeneity of Variance for Table C.32

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I enjoyed the PL approach.	Based on Mean	1.046	3	267	.373
	Based on Median	.818	3	267	.485
	Based on Median and with adjusted df	.818	3	264.194	.485
	Based on trimmed mean	1.062	3	267	.366

Table C.34 Tukey/Dunnet Test for Table C.32

Multiple Comparisons							
Dependent Variable: I enjoyed the PL approach.							
	(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	Missing	Low	-.661	.596	.684	-2.20	.88
		Med	-.373	.467	.855	-1.58	.83
		High	-.500	.462	.701	-1.69	.69
	Low	Missing	.661	.596	.684	-.88	2.20
		Med	.288	.447	.917	-.87	1.44
		High	.161	.441	.983	-.98	1.30
	Med	Missing	.373	.467	.855	-.83	1.58
		Low	-.288	.447	.917	-1.44	.87
		High	-.127	.241	.952	-.75	.50
	High	Missing	.500	.462	.701	-.69	1.69
		Low	-.161	.441	.983	-1.30	.98
		Med	.127	.241	.952	-.50	.75
Dunnett T3	Missing	Low	-.661	.626	.868	-2.40	1.07
		Med	-.373	.472	.961	-1.72	.97
		High	-.500	.462	.852	-1.83	.83
	Low	Missing	.661	.626	.868	-1.07	2.40
		Med	.288	.486	.991	-1.09	1.67
		High	.161	.476	1.000	-1.20	1.52
	Med	Missing	.373	.472	.961	-.97	1.72
		Low	-.288	.486	.991	-1.67	1.09
		High	-.127	.240	.996	-.77	.51
	High	Missing	.500	.462	.852	-.83	1.83
		Low	-.161	.476	1.000	-1.52	1.20
		Med	.127	.240	.996	-.51	.77

Table C.35 Descriptive for Enjoyment Variable

Statistics		
I enjoyed the PL approach.		
N	Valid	271
	Missing	0
Mean		4.32
Std. Error of Mean		.111
Median		4.00
Std. Deviation		1.828
Skewness		-.258
Std. Error of Skewness		.148
Kurtosis		-.845
Std. Error of Kurtosis		.295

Table C.36 PL Enjoyment by GPA and Course Type

		Low GPA		Med GPA		No GPA		Top GPA	
		HUM	STEM	HUM	STEM	HUM	STEM	HUM	STEM
1	N	1	1	2	8	2	3	1	12
	%	5.9	33.3	4.5	12.5	28.6	9.4	2.4	13.6
2	N	0	0	7	7	0	3	1	6
	%	.0	.0	15.9	10.9	.0	9.4	2.4	6.8
3	N	4	1	4	10	1	4	4	9
	%	23.5	33.3	9.1	15.6	14.3	12.5	9.8	10.2
4	N	3	1	7	10	1	7	13	19
	%	17.6	33.3	15.9	15.6	14.3	21.9	31.7	21.6
5	N	2	0	10	10	1	9	11	17
	%	11.8	.0	22.7	15.6	14.3	28.1	26.8	19.3
6	N	1	0	6	10	1	3	4	16
	%	5.9	.0	13.6	15.6	14.3	9.4	9.8	18.2
7	N	6	0	8	9	1	3	7	9
	%	35.3	.0	18.2	14.1	14.3	9.4	17.1	10.2
Total	N	17	3	44	64	7	32	41	88
	Mn	4.9	2.7	4.5	4.1	3.9	4.2	4.8	4.2
	Md	5	3	5	4	4	4	5	4
	SD	1.9	1.5	1.8	2.0	2.3	1.7	1.4	1.9

Mn: Mean, Md: Median, SD: Standard deviation

Table C.37 2-way ANOVA for Course Type, GPA and Enjoyment

Tests of Between-Subjects Effects					
Dependent Variable: I enjoyed the PL approach.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	30.333[a]	7	4.333	1.306	.247
Intercept	1542.771	1	1542.771	465.108	.000
GPALevel	9.294	3	3.098	.934	.425
COURSETYPE	13.829	1	13.829	4.169	.042
GPALevel * COURSETYPE	9.089	3	3.030	.913	.435
Error	872.375	263	3.317		
Total	5954.000	271			
Corrected Total	902.708	270			

Table C.38 PL Approach Perceived Learning

Overall I feel the PL approach helped me learn more.	1	N	23
		%	7.8
	2	N	20
		%	6.8
	3	N	40
		%	13.5
	4	N	68
		%	23.0
	5	N	58
		%	19.6
	6	N	53
		%	17.9
	7	N	34
		%	11.5
	Total	N	296
		Mean	4.4
		Median	4
		SD	1.7

Table C.39 Descriptive for Perceived Learning Variable

Statistics		
Overall I feel the PL approach helped me learn more.		
N	Valid	271
	Missing	0
Mean		4.37
Std. Error of Mean		.105
Median		4.00
Std. Deviation		1.725
Skewness		-.289
Std. Error of Skewness		.148
Kurtosis		-.702
Std. Error of Kurtosis		.295

Table C.40 PL Approach Perceived Learning by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	2	3	7	10
	%	11.1	15.0	6.5	7.9
2	N	1	0	11	7
	%	5.6	.0	10.3	5.6
3	N	3	3	15	16
	%	16.7	15.0	14.0	12.7
4	N	4	5	25	29
	%	22.2	25.0	23.4	23.0
5	N	5	1	18	26
	%	27.8	5.0	16.8	20.6
6	N	2	4	18	24
	%	11.1	20.0	16.8	19.0
7	N	1	4	13	14
	%	5.6	20.0	12.1	11.1
Total	Count	18	20	107	126
	Mean	4.1	4.4	4.3	4.4
	Median	4	4	4	5
	Mode	5	4	4	4
	SD	1.7	2.0	1.7	1.7

Table C.41 Chi-Squared Test for Table C.40

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	11.207
df	18
Sig.	.885[a]

Results are based on nonempty rows and columns in each innermost subtable.
a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

Table C.42 ANOVA for Table C.40

ANOVA					
Overall I feel the PL approach helped me learn more.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.801	3	.934	.311	.817
Within Groups	800.557	267	2.998		
Total	803.358	270			

Table C.43 Homogeneity of Variance for Table C.42

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Overall I feel the PL approach helped me learn more.	Based on Mean	.713	3	267	.545
	Based on Median	.439	3	267	.725
	Based on Median and with adjusted df	.439	3	264.457	.725
	Based on trimmed mean	.739	3	267	.529

Table C.44 Tukey/Dunnet Test for Table C.42

Multiple Comparisons							
Dependent Variable: Overall I feel the PL approach helped me learn more.							
	(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	Missing	Low	-.394	.563	.897	-1.85	1.06
		Med	-.272	.441	.927	-1.41	.87
		High	-.389	.436	.809	-1.52	.74
	Low	Missing	.394	.563	.897	-1.06	1.85
		Med	.123	.422	.991	-.97	1.21
		High	.006	.417	1.000	-1.07	1.08
	Med	Missing	.272	.441	.927	-.87	1.41
		Low	-.123	.422	.991	-1.21	.97
		High	-.117	.228	.955	-.71	.47
	High	Missing	.389	.436	.809	-.74	1.52
		Low	-.006	.417	1.000	-1.08	1.07
		Med	.117	.228	.955	-.47	.71
Dunnett T3	Missing	Low	-.394	.601	.985	-2.06	1.27
		Med	-.272	.426	.986	-1.49	.94
		High	-.389	.420	.921	-1.59	.81
	Low	Missing	.394	.601	.985	-1.27	2.06
		Med	.123	.486	1.000	-1.26	1.51
		High	.006	.480	1.000	-1.37	1.38
	Med	Missing	.272	.426	.986	-.94	1.49
		Low	-.123	.486	1.000	-1.51	1.26
		High	-.117	.225	.996	-.71	.48
	High	Missing	.389	.420	.921	-.81	1.59
		Low	-.006	.480	1.000	-1.38	1.37
		Med	.117	.225	.996	-.48	.71

Table C.45 PL Approach Perceived Learning by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	3	5	6	2	1	2	1	2
	%	10.3	15.6	8.3	18.2	2.9	7.7	3.4	5.4
2	N	3	3	7	0	1	2	3	0
	%	10.3	9.4	9.7	.0	2.9	7.7	10.3	.0
3	N	6	6	3	3	9	2	4	4
	%	20.7	18.8	4.2	27.3	25.7	7.7	13.8	10.8
4	N	7	7	17	3	12	7	5	5
	%	24.1	21.9	23.6	27.3	34.3	26.9	17.2	13.5
5	N	2	4	20	1	5	5	6	7
	%	6.9	12.5	27.8	9.1	14.3	19.2	20.7	18.9
6	N	7	6	12	1	5	3	4	10
	%	24.1	18.8	16.7	9.1	14.3	11.5	13.8	27.0
7	N	1	1	7	1	2	5	6	9
	%	3.4	3.1	9.7	9.1	5.7	19.2	20.7	24.3
Total	Count	29	32	72	11	35	26	29	37
	Mean	3.9	3.8	4.4	3.7	4.2	4.5	4.7	5.2
	Median	4	4	5	4	4	5	5	6
	Mode	4[a]	4	5	3[a]	4	4	5[a]	6
	SD	1.7	1.8	1.7	1.8	1.4	1.8	1.8	1.6

a. Multiple modes exist. The smallest value is shown

Table C.46 Chi-Squared Test for Table C.45

Pearson Chi-Square Tests	
	Course
Chi-square	53.209
df	42
Sig.	.115[a,b]

Results are based on nonempty rows and columns in each innermost subtable.
a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.
b. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.47 ANOVA for Table C.45

ANOVA					
Overall I feel the PL approach helped me learn more.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.525	7	7.361	2.575	.014
Within Groups	751.833	263	2.859		
Total	803.358	270			

Table C.48 Homogeneity of Variance for Table C.47

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Overall I feel the PL approach helped me learn more.	Based on Mean	.642	7	263	.721
	Based on Median	.589	7	263	.765
	Based on Median and with adjusted df	.589	7	251.914	.765
	Based on trimmed mean	.633	7	263	.728

Table C.49a Tukey Test Part 1 for Table C.47

Multiple Comparisons							
Dependent Variable: Overall I feel the PL approach helped me learn more.							
			Mean			95% Confidence Interval	
	(I) Course	(J) Course	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	STEM 3	STEM 4	.181	.433	1.000	-1.14	1.51
		STEM 1	-.486	.372	.896	-1.62	.65
		HUM 1	.204	.599	1.000	-1.63	2.03
		HUM 2	-.269	.425	.998	-1.57	1.03
		HUM 4	-.607	.457	.887	-2.00	.79
		STEM 2	-.724	.444	.731	-2.08	.63
		HUM 3	-1.258	.419	.058	-2.54	.02
	STEM 4	STEM 3	-.181	.433	1.000	-1.51	1.14
		STEM 1	-.667	.359	.582	-1.76	.43
		HUM 1	.023	.591	1.000	-1.78	1.83
		HUM 2	-.450	.414	.959	-1.71	.81
		HUM 4	-.788	.446	.643	-2.15	.58
		STEM 2	-.905	.433	.425	-2.23	.42
		HUM 3	-1.439*	.408	.012	-2.69	-.19
	STEM 1	STEM 3	.486	.372	.896	-.65	1.62
		STEM 4	.667	.359	.582	-.43	1.76
		HUM 1	.689	.547	.913	-.98	2.36
		HUM 2	.217	.348	.999	-.85	1.28
		HUM 4	-.122	.387	1.000	-1.30	1.06
		STEM 2	-.239	.372	.998	-1.37	.90
		HUM 3	-.773	.342	.321	-1.82	.27
	HUM 1	STEM 3	-.204	.599	1.000	-2.03	1.63
		STEM 4	-.023	.591	1.000	-1.83	1.78
		STEM 1	-.689	.547	.913	-2.36	.98
		HUM 2	-.473	.584	.993	-2.26	1.31
		HUM 4	-.811	.608	.885	-2.67	1.05
		STEM 2	-.928	.599	.779	-2.76	.90
		HUM 3	-1.462	.581	.193	-3.24	.31

*. The mean difference is significant at the 0.05 level.

Table C.49b Tukey Test Part 2 for Table C.47

Multiple Comparisons							
Dependent Variable: Overall I feel the PL approach helped me learn more.							
						95% Confidence Interval	
	(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	HUM 2	STEM 3	.269	.425	.998	-1.03	1.57
		STEM 4	.450	.414	.959	-.81	1.71
		STEM 1	-.217	.348	.999	-1.28	.85
		HUM 1	.473	.584	.993	-1.31	2.26
		HUM 4	-.338	.438	.994	-1.68	1.00
		STEM 2	-.455	.425	.962	-1.75	.84
		HUM 3	-.989	.399	.208	-2.21	.23
	HUM 4	STEM 3	.607	.457	.887	-.79	2.00
		STEM 4	.788	.446	.643	-.58	2.15
		STEM 1	.122	.387	1.000	-1.06	1.30
		HUM 1	.811	.608	.885	-1.05	2.67
		HUM 2	.338	.438	.994	-1.00	1.68
		STEM 2	-.117	.457	1.000	-1.51	1.28
		HUM 3	-.651	.433	.805	-1.97	.67
	STEM 2	STEM 3	.724	.444	.731	-.63	2.08
		STEM 4	.905	.433	.425	-.42	2.23
		STEM 1	.239	.372	.998	-.90	1.37
		HUM 1	.928	.599	.779	-.90	2.76
		HUM 2	.455	.425	.962	-.84	1.75
		HUM 4	.117	.457	1.000	-1.28	1.51
		HUM 3	-.534	.419	.908	-1.82	.75
	HUM 3	STEM 3	1.258	.419	.058	-.02	2.54
		STEM 4	1.439*	.408	.012	.19	2.69
		STEM 1	.773	.342	.321	-.27	1.82
		HUM 1	1.462	.581	.193	-.31	3.24
		HUM 2	.989	.399	.208	-.23	2.21
		HUM 4	.651	.433	.805	-.67	1.97
		STEM 2	.534	.419	.908	-.75	1.82

*. The mean difference is significant at the 0.05 level.

Table C.50 Two-way ANOVA for Perceived Learning by Course Type and GPA

Tests of Between-Subjects Effects					
Dependent Variable: Overall I feel the PL approach helped me learn more.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21.715[a]	7	3.102	1.044	.401
Intercept	1588.578	1	1588.578	534.510	.000
GPALevel	7.015	3	2.338	.787	.502
COURSETYPE	4.047	1	4.047	1.362	.244
GPALevel * COURSETYPE	11.369	3	3.790	1.275	.283
Error	781.643	263	2.972		
Total	5985.000	271			
Corrected Total	803.358	270			

a. R Squared = .027 (Adjusted R Squared = .001)

Table C.51 PL Perceived Learning Results by Activity

		N	%
I learned from having to make up problems.	1	12	4.4%
	2	11	4.1%
	3	21	7.7%
	4	60	22.1%
	5	65	24.0%
	6	60	22.1%
	7	42	15.5%
	Total	271	
I learned from solving problems with the PL approach.	1	13	4.8%
	2	25	9.2%
	3	27	10.0%
	4	59	21.8%
	5	65	24.0%
	6	49	18.1%
	7	33	12.2%
	Total	271	
I learned from grading other students' solutions.	1	19	7.0%
	2	21	7.7%
	3	33	12.2%
	4	48	17.7%
	5	66	24.4%
	6	43	15.9%
	7	41	15.1%
	Total	271	
I learned from reading other people’s problems, solutions and comments on grades.	1	13	4.8%
	2	14	5.2%
	3	27	10.0%
	4	52	19.2%
	5	60	22.1%
	6	59	21.8%
	7	46	17.0%
	Total	271	

Table C.52 Descriptive for Perceived Learning by Activity Type

Statistics					
		I learned from having to make up problems.	I learned from solving problems with the PL approach.	I learned from grading other students' solutions.	I learned from reading other people's problems, solutions and comments on grades.
N	Valid	271	271	271	271
	Missing	0	0	0	0
Mean		4.86	4.54	4.53	4.82
Std. Error of Mean		.095	.099	.106	.100
Median		5.00	5.00	5.00	5.00
Std. Deviation		1.560	1.637	1.742	1.642
Skewness		-.601	-.376	-.377	-.551
Std. Error of Skewness		.148	.148	.148	.148
Kurtosis		-.059	-.569	-.682	-.365
Std. Error of Kurtosis		.295	.295	.295	.295

Table C.53 Perceived Learning by Course Type Part 1

			Course Type	
			HUM	STEM
I learned from having to make up problems.	1	N	4	8
		%	3.7%	4.9%
	2	N	5	6
		%	4.6%	3.7%
	3	N	9	12
		%	8.3%	7.4%
	4	N	28	32
		%	25.7%	19.8%
	5	N	26	39
		%	23.9%	24.1%
	6	N	15	45
		%	13.8%	27.8%
	7	N	22	20
		%	20.2%	12.3%
	Total	Mean	4.83	4.87
		Median	5.0	5.0

Table C.54 Perceived Learning by Course Type Part 2

			Course Type	
			HUM	STEM
I learned from solving problems with the PL approach.	1	N	7	6
		%	6.4%	3.7%
	2	N	6	19
		%	5.5%	11.7%
	3	N	10	17
		%	9.2%	10.5%
	4	N	30	29
		%	27.5%	17.9%
	5	N	25	40
		%	22.9%	24.7%
	6	N	15	34
		%	13.8%	21.0%
	7	N	16	17
		%	14.7%	10.5%
	Total	Mean	4.55	4.53
		Median	5.0	5.0

Table C.55 Perceived Learning by Course Type Part 3

			Course Type	
			HUM	STEM
I learned from grading other students' solutions.	1	N	7	12
		%	6.4%	7.4%
	2	N	4	17
		%	3.7%	10.5%
	3	N	10	23
		%	9.2%	14.2%
	4	N	21	27
		%	19.3%	16.7%
	5	N	25	41
		%	22.9%	25.3%
	6	N	19	24
		%	17.4%	14.8%
	7	N	23	18
		%	21.1%	11.1%
	Total	Mean	4.85	4.31
		Median	5.0	5.0

Table C.56 Perceived Learning by Course Type Part 4

			Course Type	
			HUM	STEM
I learned from reading other people's problems, solutions and comments on grades.	1	N	5	8
		%	4.6%	4.9%
	2	N	3	11
		%	2.8%	6.8%
	3	N	6	21
		%	5.5%	13.0%
	4	N	18	34
		%	16.5%	21.0%
	5	N	24	36
		%	22.0%	22.2%
	6	N	31	28
		%	28.4%	17.3%
	7	N	22	24
		%	20.2%	14.8%
	Total	Mean	5.15	4.60
		Median	5.0	5.0

Table C.57 Perceived Learning from Making Problem by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	3	3	1	1	1	0	1	2
	%	10.3	9.4	1.4	9.1	2.9	.0	3.4	5.4
2	N	1	1	3	1	3	0	1	1
	%	3.4	3.1	4.2	9.1	8.6	.0	3.4	2.7
3	N	2	6	3	0	5	1	1	3
	%	6.9	18.8	4.2	.0	14.3	3.8	3.4	8.1
4	N	9	7	9	5	8	11	7	4
	%	31.0	21.9	12.5	45.5	22.9	42.3	24.1	10.8
5	N	2	5	23	2	10	6	9	8
	%	6.9	15.6	31.9	18.2	28.6	23.1	31.0	21.6
6	N	9	8	23	2	2	3	5	8
	%	31.0	25.0	31.9	18.2	5.7	11.5	17.2	21.6
7	N	3	2	10	0	6	5	5	11
	%	10.3	6.3	13.9	.0	17.1	19.2	17.2	29.7
Total	Count	29	32	72	11	35	26	29	37
	Mean	4.6	4.3	5.2	4.1	4.5	5.0	5.0	5.2
	Median	4	4	5	4	5	5	5	6
	Mode	4[a]	6	5[a]	4	5	4	5	7
	SD	1.8	1.7	1.3	1.5	1.6	1.2	1.5	1.7

a. Multiple modes exist. The smallest value is shown

Table C.58 Chi-Squared Test for Table C.57

Pearson Chi-Square Tests	
	Course
Chi-square	62.391
df	42
Sig.	.022[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.
*. The Chi-square statistic is significant at the .05 level.
b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.
c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.59 ANOVA for C.57

ANOVA					
I learned from having to make up problems.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.037	7	5.434	2.307	.027
Within Groups	619.351	263	2.355		
Total	657.387	270			

Table C.60 Homogeneity of Variance for Table C.59

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from having to make up problems.	Based on Mean	1.573	7	263	.144
	Based on Median	1.226	7	263	.288
	Based on Median and with adjusted df	1.226	7	238.831	.289
	Based on trimmed mean	1.518	7	263	.161

Table C.61a Tukey Test Part 1 for Table C.59

Multiple Comparisons						
Dependent Variable: I learned from having to make up problems.						
Tukey HSD						
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
STEM 3	STEM 4	.239	.393	.999	-.96	1.44
	STEM 1	-.657	.338	.521	-1.69	.37
	HUM 1	.461	.543	.990	-1.20	2.12
	HUM 2	.037	.385	1.000	-1.14	1.21
	HUM 4	-.448	.414	.960	-1.71	.82
	STEM 2	-.414	.403	.970	-1.65	.82
	HUM 3	-.692	.381	.609	-1.85	.47
STEM 4	STEM 3	-.239	.393	.999	-1.44	.96
	STEM 1	-.896	.326	.113	-1.89	.10
	HUM 1	.222	.536	1.000	-1.42	1.86
	HUM 2	-.202	.375	.999	-1.35	.95
	HUM 4	-.687	.405	.689	-1.93	.55
	STEM 2	-.653	.393	.713	-1.86	.55
	HUM 3	-.931	.370	.195	-2.06	.20
STEM 1	STEM 3	.657	.338	.521	-.37	1.69
	STEM 4	.896	.326	.113	-.10	1.89
	HUM 1	1.117	.497	.326	-.40	2.64
	HUM 2	.694	.316	.358	-.27	1.66
	HUM 4	.208	.351	.999	-.86	1.28
	STEM 2	.243	.338	.996	-.79	1.27
	HUM 3	-.035	.310	1.000	-.98	.91
HUM 1	STEM 3	-.461	.543	.990	-2.12	1.20
	STEM 4	-.222	.536	1.000	-1.86	1.42
	STEM 1	-1.117	.497	.326	-2.64	.40
	HUM 2	-.423	.530	.993	-2.04	1.20
	HUM 4	-.909	.552	.721	-2.60	.78
	STEM 2	-.875	.543	.744	-2.53	.79
	HUM 3	-1.152	.527	.363	-2.76	.46

Table C.61b Tukey Test Part 2 for Table C.59

Multiple Comparisons						
Dependent Variable: I learned from having to make up problems.						
Tukey HSD						
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
HUM 2	STEM 3	-.037	.385	1.000	-1.21	1.14
	STEM 4	.202	.375	.999	-.95	1.35
	STEM 1	-.694	.316	.358	-1.66	.27
	HUM 1	.423	.530	.993	-1.20	2.04
	HUM 4	-.486	.397	.925	-1.70	.73
	STEM 2	-.451	.385	.939	-1.63	.73
	HUM 3	-.729	.362	.474	-1.83	.38
HUM 4	STEM 3	.448	.414	.960	-.82	1.71
	STEM 4	.688	.405	.689	-.55	1.93
	STEM 1	-.208	.351	.999	-1.28	.86
	HUM 1	.909	.552	.721	-.78	2.60
	HUM 2	.486	.397	.925	-.73	1.70
	STEM 2	.034	.414	1.000	-1.23	1.30
	HUM 3	-.243	.393	.999	-1.44	.96
STEM 2	STEM 3	.414	.403	.970	-.82	1.65
	STEM 4	.653	.393	.713	-.55	1.86
	STEM 1	-.243	.338	.996	-1.27	.79
	HUM 1	.875	.543	.744	-.79	2.53
	HUM 2	.451	.385	.939	-.73	1.63
	HUM 4	-.034	.414	1.000	-1.30	1.23
	HUM 3	-.278	.381	.996	-1.44	.89
HUM 3	STEM 3	.692	.381	.609	-.47	1.85
	STEM 4	.931	.370	.195	-.20	2.06
	STEM 1	.035	.310	1.000	-.91	.98
	HUM 1	1.152	.527	.363	-.46	2.76
	HUM 2	.729	.362	.474	-.38	1.83
	HUM 4	.243	.393	.999	-.96	1.44
	STEM 2	.278	.381	.996	-.89	1.44

Table C.62 Perceived Learning from Making Problem by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	2	2	4	4
	%	11.1	10.0	3.7	3.2
2	N	0	3	4	4
	%	.0	15.0	3.7	3.2
3	N	0	0	11	10
	%	.0	.0	10.3	7.9
4	N	4	5	28	23
	%	22.2	25.0	26.2	18.3
5	N	8	3	24	30
	%	44.4	15.0	22.4	23.8
6	N	3	1	20	36
	%	16.7	5.0	18.7	28.6
7	N	1	6	16	19
	%	5.6	30.0	15.0	15.1
Total	Count	18	20	107	126
	Mean	4.6	4.6	4.8	5.0
	Median	5	5	5	5
	Mode	5	7	4	6
	SD	1.5	2.1	1.5	1.5

Table C.63 Chi-Squared Test for Table C.62

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	29.878
df	18
Sig.	.039[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.
*. The Chi-square statistic is significant at the .05 level.
b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.
c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.64 ANOVA for Table C.62

ANOVA					
I learned from having to make up problems.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.549	3	2.516	1.034	.378
Within Groups	649.839	267	2.434		
Total	657.387	270			

Table C.65 Homogeneity of Variance for Table C.64

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from having to make up problems.	Based on Mean	2.506	3	267	.059
	Based on Median	2.613	3	267	.052
	Based on Median and with adjusted df	2.613	3	257.125	.052
	Based on trimmed mean	2.456	3	267	.063

Table C.66 Tukey Test for Table C.64

Multiple Comparisons						
Dependent Variable: I learned from having to make up problems.						
Tukey HSD						
(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Missing	Low	.061	.507	.999	-1.25	1.37
	Med	-.146	.397	.983	-1.17	.88
	High	-.413	.393	.720	-1.43	.60
Low	Missing	-.061	.507	.999	-1.37	1.25
	Med	-.207	.380	.948	-1.19	.78
	High	-.474	.376	.588	-1.44	.50
Med	Missing	.146	.397	.983	-.88	1.17
	Low	.207	.380	.948	-.78	1.19
	High	-.267	.205	.563	-.80	.26
High	Missing	.413	.393	.720	-.60	1.43
	Low	.474	.376	.588	-.50	1.44
	Med	.267	.205	.563	-.26	.80

Table C.67 Two-way ANOVA for Perceived Learning from Making Problems by Course Type and GPA

Levene's Test of Equality of Error Variances[a,b]					
		Levene Statistic	df1	df2	Sig.
I learned from having to make up problems.	Based on Mean	1.141	7	263	.338
	Based on Median	1.035	7	263	.407
	Based on Median and with adjusted df	1.035	7	247.514	.407
	Based on trimmed mean	1.137	7	263	.340

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Dependent variable: I learned from having to make up problems.
b. Design: Intercept + GPALevelC + COURSETYPEAllCalc + GPALevelC * COURSETYPEAllCalc

Table C.68 Perceived Learning from Solving Problems by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	2	1	1	1	1	2	2	3
	%	6.9	3.1	1.4	9.1	2.9	7.7	6.9	8.1
2	N	5	4	7	0	3	3	3	0
	%	17.2	12.5	9.7	.0	8.6	11.5	10.3	.0
3	N	2	6	7	2	8	0	2	0
	%	6.9	18.8	9.7	18.2	22.9	.0	6.9	.0
4	N	6	6	11	5	14	6	6	5
	%	20.7	18.8	15.3	45.5	40.0	23.1	20.7	13.5
5	N	7	5	20	2	6	5	8	12
	%	24.1	15.6	27.8	18.2	17.1	19.2	27.6	32.4
6	N	5	8	17	1	1	6	4	7
	%	17.2	25.0	23.6	9.1	2.9	23.1	13.8	18.9
7	N	2	2	9	0	2	4	4	10
	%	6.9	6.3	12.5	.0	5.7	15.4	13.8	27.0
Total	Count	29	32	72	11	35	26	29	37
	Mean	4.2	4.3	4.8	3.9	3.9	4.7	4.5	5.3
	Median	4	4	5	4	4	5	5	5
	Mode	5	6	5	4	4	4[a]	5	5
	SD	1.7	1.6	1.5	1.3	1.3	1.8	1.7	1.6

a. Multiple modes exist. The smallest value is shown

Table C.69 Chi-Squared Test for Table C.68

Pearson Chi-Square Tests	
	Course
Chi-square	60.859
df	42
Sig.	.030[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.

*. The Chi-square statistic is significant at the .05 level.

b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.70 ANOVA for Table C.68

ANOVA					
I learned from solving problems with the PL approach.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48.380	7	6.911	2.693	.010
Within Groups	674.963	263	2.566		
Total	723.343	270			

Table C.71 Homogeneity of Variance for Table C.69

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from solving problems with the PL approach.	Based on Mean	1.446	7	263	.187
	Based on Median	1.215	7	263	.295
	Based on Median and with adjusted df	1.215	7	252.619	.295
	Based on trimmed mean	1.393	7	263	.208

Table C.72a Tukey Test Part 1 for Table C.69

Multiple Comparisons						
Dependent Variable: I learned from solving problems with the PL approach.						
Tukey HSD						
					95% Confidence Interval	
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
STEM 3	STEM 4	-.140	.411	1.000	-1.40	1.11
	STEM 1	-.619	.352	.649	-1.70	.46
	HUM 1	.263	.567	1.000	-1.47	2.00
	HUM 2	.258	.402	.998	-.97	1.49
	HUM 4	-.481	.433	.954	-1.80	.84
	STEM 2	-.310	.421	.996	-1.60	.98
	HUM 3	-1.098	.397	.109	-2.31	.12
STEM 4	STEM 3	.140	.411	1.000	-1.11	1.40
	STEM 1	-.479	.340	.853	-1.52	.56
	HUM 1	.403	.560	.996	-1.31	2.11
	HUM 2	.398	.392	.972	-.80	1.60
	HUM 4	-.341	.423	.993	-1.63	.95
	STEM 2	-.170	.411	1.000	-1.43	1.08
	HUM 3	-.958	.387	.210	-2.14	.22
STEM 1	STEM 3	.619	.352	.649	-.46	1.70
	STEM 4	.479	.340	.853	-.56	1.52
	HUM 1	.883	.519	.686	-.70	2.47
	HUM 2	.877	.330	.141	-.13	1.89
	HUM 4	.138	.367	1.000	-.98	1.26
	STEM 2	.309	.352	.988	-.77	1.39
	HUM 3	-.479	.324	.819	-1.47	.51
HUM 1	STEM 3	-.263	.567	1.000	-2.00	1.47
	STEM 4	-.403	.560	.996	-2.11	1.31
	STEM 1	-.883	.519	.686	-2.47	.70
	HUM 2	-.005	.554	1.000	-1.70	1.69
	HUM 4	-.745	.576	.901	-2.51	1.02
	STEM 2	-.574	.567	.972	-2.31	1.16
	HUM 3	-1.361	.550	.211	-3.04	.32

*. The mean difference is significant at the 0.05 level.

Table C.72b Tukey Test Part 2 for Table C.69

Multiple Comparisons						
Dependent Variable: I learned from solving problems with the PL approach.						
Tukey HSD						
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
HUM 2	STEM 3	-.258	.402	.998	-1.49	.97
	STEM 4	-.398	.392	.972	-1.60	.80
	STEM 1	-.877	.330	.141	-1.89	.13
	HUM 1	.005	.554	1.000	-1.69	1.70
	HUM 4	-.740	.415	.632	-2.01	.53
	STEM 2	-.568	.402	.851	-1.80	.66
	HUM 3	-1.356*	.378	.009	-2.51	-.20
HUM 4	STEM 3	.481	.433	.954	-.84	1.80
	STEM 4	.341	.423	.993	-.95	1.63
	STEM 1	-.138	.367	1.000	-1.26	.98
	HUM 1	.745	.576	.901	-1.02	2.51
	HUM 2	.740	.415	.632	-.53	2.01
	STEM 2	.171	.433	1.000	-1.15	1.49
	HUM 3	-.616	.410	.805	-1.87	.64
STEM 2	STEM 3	.310	.421	.996	-.98	1.60
	STEM 4	.170	.411	1.000	-1.08	1.43
	STEM 1	-.309	.352	.988	-1.39	.77
	HUM 1	.574	.567	.972	-1.16	2.31
	HUM 2	.568	.402	.851	-.66	1.80
	HUM 4	-.171	.433	1.000	-1.49	1.15
	HUM 3	-.788	.397	.496	-2.00	.43
HUM 3	STEM 3	1.098	.397	.109	-.12	2.31
	STEM 4	.958	.387	.210	-.22	2.14
	STEM 1	.479	.324	.819	-.51	1.47
	HUM 1	1.361	.550	.211	-.32	3.04
	HUM 2	1.356*	.378	.009	.20	2.51
	HUM 4	.616	.410	.805	-.64	1.87
	STEM 2	.788	.397	.496	-.43	2.00

*. The mean difference is significant at the 0.05 level.

Table C.73 Perceived Learning from Making Problem by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	2	1	5	5
	%	11.1	5.0	4.7	4.0
2	N	1	1	10	13
	%	5.6	5.0	9.3	10.3
3	N	1	3	16	7
	%	5.6	15.0	15.0	5.6
4	N	6	4	23	26
	%	33.3	20.0	21.5	20.6
5	N	6	3	26	30
	%	33.3	15.0	24.3	23.8
6	N	2	4	12	31
	%	11.1	20.0	11.2	24.6
7	N	0	4	15	14
	%	.0	20.0	14.0	11.1
Total	Count	18	20	107	126
	Mean	4.1	4.7	4.4	4.7
	Median	4	5	4	5
	Mode	4[a]	4[a]	5	6
	SD	1.5	1.8	1.7	1.6

a. Multiple modes exist. The smallest value is shown

Table C.74 Chi-Squared Test for Table C.73

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	20.926
df	18
Sig.	.283[a,b]

Results are based on nonempty rows and columns in each innermost subtable.

a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

b. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.75 ANOVA for Table C.73

ANOVA

I learned from solving problems with the PL approach.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.441	3	3.147	1.177	.319
Within Groups	713.903	267	2.674		
Total	723.343	270			

Table C.76 Homogeneity of Variance for Table C.75

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from solving problems with the PL approach.	Based on Mean	.730	3	267	.535
	Based on Median	.695	3	267	.556
	Based on Median and with adjusted df	.695	3	266.520	.556
	Based on trimmed mean	.696	3	267	.555

Table C.77 Tukey Test for Table C.75

Multiple Comparisons						
Dependent Variable: I learned from solving problems with the PL approach.						
Tukey HSD						
(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Missing	Low	-.694	.531	.559	-2.07	.68
	Med	-.356	.417	.829	-1.43	.72
	High	-.627	.412	.426	-1.69	.44
Low	Missing	.694	.531	.559	-.68	2.07
	Med	.339	.398	.830	-.69	1.37
	High	.067	.394	.998	-.95	1.08
Med	Missing	.356	.417	.829	-.72	1.43
	Low	-.339	.398	.830	-1.37	.69
	High	-.271	.215	.588	-.83	.28
High	Missing	.627	.412	.426	-.44	1.69
	Low	-.067	.394	.998	-1.08	.95
	Med	.271	.215	.588	-.28	.83

Table C.78 Two-way ANOVA for Perceived Learning from Solving Problems by Course Type and GPA

Tests of Between-Subjects Effects					
Dependent Variable: I learned from solving problems with the PL approach.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.736[a]	7	2.391	.890	.515
Intercept	1720.969	1	1720.969	640.547	.000
GPA Level	9.084	3	3.028	1.127	.339
COURSE TYPE	.390	1	.390	.145	.704
GPA Level * COURSE TYPE	7.285	3	2.428	.904	.440
Error	706.607	263	2.687		
Total	6306.000	271			
Corrected Total	723.343	270			

a. R Squared = .023 (Adjusted R Squared = -.003)

Table C.79 Perceived Learning from Grading Others by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	3	3	4	2	0	2	2	3
	%	10.3	9.4	5.6	18.2	.0	7.7	6.9	8.1
2	N	4	2	4	1	2	1	7	0
	%	13.8	6.3	5.6	9.1	5.7	3.8	24.1	.0
3	N	2	9	8	1	4	3	4	2
	%	6.9	28.1	11.1	9.1	11.4	11.5	13.8	5.4
4	N	6	6	11	4	9	3	4	5
	%	20.7	18.8	15.3	36.4	25.7	11.5	13.8	13.5
5	N	6	6	22	2	11	4	7	8
	%	20.7	18.8	30.6	18.2	31.4	15.4	24.1	21.6
6	N	7	3	12	1	6	7	2	5
	%	24.1	9.4	16.7	9.1	17.1	26.9	6.9	13.5
7	N	1	3	11	0	3	6	3	14
	%	3.4	9.4	15.3	.0	8.6	23.1	10.3	37.8
Total	Count	29	32	72	11	35	26	29	37
	Mean	4.1	4.0	4.7	3.5	4.7	5.0	3.9	5.3
	Median	4	4	5	4	5	6	4	6
	Mode	6	3	5	4	5	6	2[a]	7
	SD	1.8	1.7	1.6	1.6	1.3	1.9	1.8	1.8

a. Multiple modes exist. The smallest value is shown

Table C.80 Chi-Squared Test for Table C.79

Pearson Chi-Square Tests	
	Course
Chi-square	64.738
df	42
Sig.	.014[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.

*. The Chi-square statistic is significant at the .05 level.

b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.81 ANOVA for Table C.79

ANOVA					
I learned from grading other students' solutions.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	69.462	7	9.923	3.479	.001
Within Groups	750.080	263	2.852		
Total	819.542	270			

Table C.82 Homogeneity of Variance for Table C.81

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from grading other students' solutions.	Based on Mean	.875	7	263	.527
	Based on Median	.884	7	263	.519
	Based on Median and with adjusted df	.884	7	248.980	.519
	Based on trimmed mean	.870	7	263	.531

Table C.83a Tukey Test Part 1 for Table C.81

Multiple Comparisons						
Dependent Variable: I learned from grading other students' solutions.						
Tukey HSD						
					95% Confidence Interval	
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
STEM 3	STEM 4	.169	.433	1.000	-1.15	1.49
	STEM 1	-.570	.371	.787	-1.71	.56
	HUM 1	.592	.598	.975	-1.23	2.42
	HUM 2	-.548	.424	.901	-1.84	.75
	HUM 4	-.824	.456	.617	-2.22	.57
	STEM 2	.276	.443	.999	-1.08	1.63
	HUM 3	-1.186	.419	.091	-2.47	.09
STEM 4	STEM 3	-.169	.433	1.000	-1.49	1.15
	STEM 1	-.740	.359	.443	-1.84	.36
	HUM 1	.423	.590	.996	-1.38	2.23
	HUM 2	-.717	.413	.664	-1.98	.55
	HUM 4	-.993	.446	.339	-2.36	.37
	STEM 2	.107	.433	1.000	-1.22	1.43
	HUM 3	-1.356*	.408	.022	-2.60	-.11
STEM 1	STEM 3	.570	.371	.787	-.56	1.71
	STEM 4	.740	.359	.443	-.36	1.84
	HUM 1	1.163	.547	.400	-.51	2.83
	HUM 2	.023	.348	1.000	-1.04	1.09
	HUM 4	-.253	.386	.998	-1.43	.93
	STEM 2	.846	.371	.310	-.29	1.98
	HUM 3	-.616	.342	.618	-1.66	.43
HUM 1	STEM 3	-.592	.598	.975	-2.42	1.23
	STEM 4	-.423	.590	.996	-2.23	1.38
	STEM 1	-1.163	.547	.400	-2.83	.51
	HUM 2	-1.140	.584	.516	-2.92	.64
	HUM 4	-1.416	.607	.281	-3.27	.44
	STEM 2	-.317	.598	.999	-2.14	1.51
	HUM 3	-1.779*	.580	.048	-3.55	-.01

*. The mean difference is significant at the 0.05 level.

Table C.83b Tukey Test Part 2 for Table C.81

Multiple Comparisons						
Dependent Variable: I learned from grading other students' solutions.						
Tukey HSD						
					95% Confidence Interval	
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
HUM 2	STEM 3	.548	.424	.901	-.75	1.84
	STEM 4	.717	.413	.664	-.55	1.98
	STEM 1	-.023	.348	1.000	-1.09	1.04
	HUM 1	1.140	.584	.516	-.64	2.92
	HUM 4	-.276	.437	.998	-1.61	1.06
	STEM 2	.824	.424	.523	-.47	2.12
	HUM 3	-.639	.398	.748	-1.86	.58
HUM 4	STEM 3	.824	.456	.617	-.57	2.22
	STEM 4	.993	.446	.339	-.37	2.36
	STEM 1	.253	.386	.998	-.93	1.43
	HUM 1	1.416	.607	.281	-.44	3.27
	HUM 2	.276	.437	.998	-1.06	1.61
	STEM 2	1.099	.456	.241	-.29	2.49
	HUM 3	-.363	.432	.991	-1.68	.96
STEM 2	STEM 3	-.276	.443	.999	-1.63	1.08
	STEM 4	-.107	.433	1.000	-1.43	1.22
	STEM 1	-.846	.371	.310	-1.98	.29
	HUM 1	.317	.598	.999	-1.51	2.14
	HUM 2	-.824	.424	.523	-2.12	.47
	HUM 4	-1.099	.456	.241	-2.49	.29
	HUM 3	-1.462*	.419	.013	-2.74	-.18
HUM 3	STEM 3	1.186	.419	.091	-.09	2.47
	STEM 4	1.356*	.408	.022	.11	2.60
	STEM 1	.616	.342	.618	-.43	1.66
	HUM 1	1.779*	.580	.048	.01	3.55
	HUM 2	.639	.398	.748	-.58	1.86
	HUM 4	.363	.432	.991	-.96	1.68
	STEM 2	1.462*	.419	.013	.18	2.74

*. The mean difference is significant at the 0.05 level.

Table C.84 Perceived Learning from Grading Others by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	3	1	8	7
	%	16.7	5.0	7.5	5.6
2	N	0	2	10	9
	%	.0	10.0	9.3	7.1
3	N	3	3	18	9
	%	16.7	15.0	16.8	7.1
4	N	5	1	14	28
	%	27.8	5.0	13.1	22.2
5	N	6	3	23	34
	%	33.3	15.0	21.5	27.0
6	N	1	4	18	20
	%	5.6	20.0	16.8	15.9
7	N	0	6	16	19
	%	.0	30.0	15.0	15.1
Total	Count	18	20	107	126
	Mean	3.8	4.9	4.4	4.7
	Median	4	6	5	5
	Mode	5	7	5	5
	SD	1.5	2.0	1.8	1.6

Table C.85 Chi-Squared Test for Table C.84

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	24.566
df	18
Sig.	.137[a]

Results are based on nonempty rows and columns in each innermost subtable.

a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

Table C.86 ANOVA for C.84

ANOVA					
I learned from grading other students' solutions.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.081	3	5.694	1.894	.131
Within Groups	802.461	267	3.005		
Total	819.542	270			

Table C.87 Homogeneity of Variance for Table C.86

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from grading other students' solutions.	Based on Mean	1.957	3	267	.121
	Based on Median	1.698	3	267	.168
	Based on Median and with adjusted df	1.698	3	265.858	.168
	Based on trimmed mean	1.967	3	267	.119

Table C.88 Tukey Test for Table C.86

Multiple Comparisons						
Dependent Variable: I learned from grading other students' solutions.						
Tukey HSD						
(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Missing	Low	-1.172	.563	.162	-2.63	.28
	Med	-.643	.442	.466	-1.78	.50
	High	-.881	.437	.184	-2.01	.25
Low	Missing	1.172	.563	.162	-.28	2.63
	Med	.529	.422	.593	-.56	1.62
	High	.291	.417	.898	-.79	1.37
Med	Missing	.643	.442	.466	-.50	1.78
	Low	-.529	.422	.593	-1.62	.56
	High	-.238	.228	.723	-.83	.35
High	Missing	.881	.437	.184	-.25	2.01
	Low	-.291	.417	.898	-1.37	.79
	Med	.238	.228	.723	-.35	.83

Table C.89 Two-way ANOVA for Perceived Learning from Grading Others by Course Type and GPA

Tests of Between-Subjects Effects					
Dependent Variable: I learned from grading other students' solutions.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	43.399[a]	7	6.200	2.101	.044
Intercept	1697.217	1	1697.217	575.110	.000
GPALevelC	16.478	3	5.493	1.861	.137
COURSETYPEAllCalc	10.180	1	10.180	3.450	.064
GPALevelC * COURSETYPEAllCalc	8.403	3	2.801	.949	.417
Error	776.143	263	2.951		
Total	6375.000	271			
Corrected Total	819.542	270			

a. R Squared = .053 (Adjusted R Squared = .028)

Table C.90 Perceived Learning from Viewing Others by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	3	4	0	1	0	2	1	2
	%	10.3	12.5	.0	9.1	.0	7.7	3.4	5.4
2	N	4	1	2	0	1	1	4	1
	%	13.8	3.1	2.8	.0	2.9	3.8	13.8	2.7
3	N	1	6	11	2	3	1	3	0
	%	3.4	18.8	15.3	18.2	8.6	3.8	10.3	.0
4	N	9	6	16	4	8	3	3	3
	%	31.0	18.8	22.2	36.4	22.9	11.5	10.3	8.1
5	N	3	6	19	2	9	4	8	9
	%	10.3	18.8	26.4	18.2	25.7	15.4	27.6	24.3
6	N	6	5	10	2	10	11	7	8
	%	20.7	15.6	13.9	18.2	28.6	42.3	24.1	21.6
7	N	3	4	14	0	4	4	3	14
	%	10.3	12.5	19.4	.0	11.4	15.4	10.3	37.8
Total	Count	29	32	72	11	35	26	29	37
	Mean	4.2	4.3	4.9	4.1	5.0	5.1	4.6	5.6
	Median	4	4	5	4	5	6	5	6
	Mode	4	3[a]	5	4	6	6	5	7
	SD	1.9	1.8	1.4	1.4	1.3	1.7	1.7	1.6

a. Multiple modes exist. The smallest value is shown

Table C.91 Chi-Squared Test for Table C.90

Pearson Chi-Square Tests	
	Course
Chi-square	69.385
df	42
Sig.	.005[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.

*. The Chi-square statistic is significant at the .05 level.

b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.92 ANOVA for C.90

ANOVA

I learned from reading other people's problems, solutions and comments on grades.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	55.394	7	7.913	3.094	.004
Within Groups	672.746	263	2.558		
Total	728.140	270			

Table C.93 Homogeneity of Variance for Table C.92

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
I learned from reading other people's problems, solutions and comments on grades.	Based on Mean	1.295	7	263	.253
	Based on Median	.892	7	263	.513
	Based on Median and with adjusted df	.892	7	221.986	.514
	Based on trimmed mean	1.241	7	263	.281

Table C.94a Tukey Test Part 1 for Table C.92

Multiple Comparisons						
Dependent Variable: I learned from reading other people's problems, solutions and comments on grades.						
Tukey HSD						
		Mean			95% Confidence Interval	
		Difference	Std.		Lower	Upper
(I) Course	(J) Course	(I-J)	Error	Sig.	Bound	Bound
STEM 3	STEM 4	-.043	.410	1.000	-1.30	1.21
	STEM 1	-.710	.352	.472	-1.78	.37
	HUM 1	.116	.566	1.000	-1.61	1.85
	HUM 2	-.822	.402	.453	-2.05	.41
	HUM 4	-.908	.432	.416	-2.23	.41
	STEM 2	-.379	.420	.986	-1.66	.90
	HUM 3	-1.388*	.397	.013	-2.60	-.18
STEM 4	STEM 3	.043	.410	1.000	-1.21	1.30
	STEM 1	-.667	.340	.510	-1.70	.37
	HUM 1	.159	.559	1.000	-1.55	1.87
	HUM 2	-.779	.391	.490	-1.97	.42
	HUM 4	-.865	.422	.451	-2.16	.42
	STEM 2	-.336	.410	.992	-1.59	.92
	HUM 3	-1.345*	.386	.013	-2.52	-.16
STEM 1	STEM 3	.710	.352	.472	-.37	1.78
	STEM 4	.667	.340	.510	-.37	1.70
	HUM 1	.826	.518	.753	-.76	2.41
	HUM 2	-.112	.330	1.000	-1.12	.90
	HUM 4	-.199	.366	.999	-1.32	.92
	STEM 2	.330	.352	.982	-.74	1.41
	HUM 3	-.678	.324	.421	-1.67	.31
HUM 1	STEM 3	-.116	.566	1.000	-1.85	1.61
	STEM 4	-.159	.559	1.000	-1.87	1.55
	STEM 1	-.826	.518	.753	-2.41	.76
	HUM 2	-.938	.553	.690	-2.63	.75
	HUM 4	-1.024	.575	.634	-2.78	.73
	STEM 2	-.495	.566	.988	-2.23	1.24
	HUM 3	-1.504	.549	.116	-3.18	.17

*. The mean difference is significant at the 0.05 level.

Table C.94b Tukey Test Part 2 for Table C.92

Multiple Comparisons						
Dependent Variable: I learned from reading other people's problems, solutions and comments on grades.						
Tukey HSD						
					95% Confidence Interval	
(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
HUM 2	STEM 3	.822	.402	.453	-.41	2.05
	STEM 4	.779	.391	.490	-.42	1.97
	STEM 1	.112	.330	1.000	-.90	1.12
	HUM 1	.938	.553	.690	-.75	2.63
	HUM 4	-.087	.414	1.000	-1.35	1.18
	STEM 2	.442	.402	.956	-.78	1.67
	HUM 3	-.566	.377	.807	-1.72	.59
HUM 4	STEM 3	.908	.432	.416	-.41	2.23
	STEM 4	.865	.422	.451	-.42	2.16
	STEM 1	.199	.366	.999	-.92	1.32
	HUM 1	1.024	.575	.634	-.73	2.78
	HUM 2	.087	.414	1.000	-1.18	1.35
	STEM 2	.529	.432	.924	-.79	1.85
	HUM 3	-.479	.409	.940	-1.73	.77
STEM 2	STEM 3	.379	.420	.986	-.90	1.66
	STEM 4	.336	.410	.992	-.92	1.59
	STEM 1	-.330	.352	.982	-1.41	.74
	HUM 1	.495	.566	.988	-1.24	2.23
	HUM 2	-.442	.402	.956	-1.67	.78
	HUM 4	-.529	.432	.924	-1.85	.79
	HUM 3	-1.008	.397	.183	-2.22	.20
HUM 3	STEM 3	1.388*	.397	.013	.18	2.60
	STEM 4	1.345*	.386	.013	.16	2.52
	STEM 1	.678	.324	.421	-.31	1.67
	HUM 1	1.504	.549	.116	-.17	3.18
	HUM 2	.566	.377	.807	-.59	1.72
	HUM 4	.479	.409	.940	-.77	1.73
	STEM 2	1.008	.397	.183	-.20	2.22

*. The mean difference is significant at the 0.05 level.

Table C.95 Perceived Learning from Viewing Others by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	1	1	7	4
	%	5.6	5.0	6.5	3.2
2	N	0	0	7	7
	%	.0	.0	6.5	5.6
3	N	2	3	11	11
	%	11.1	15.0	10.3	8.7
4	N	6	2	16	28
	%	33.3	10.0	15.0	22.2
5	N	5	1	27	27
	%	27.8	5.0	25.2	21.4
6	N	4	7	18	30
	%	22.2	35.0	16.8	23.8
7	N	0	6	21	19
	%	.0	30.0	19.6	15.1
Total	Count	18	20	107	126
	Mean	4.4	5.4	4.7	4.8
	Median	5	6	5	5
	Mode	4	6	5	6
	SD	1.3	1.8	1.8	1.6

Table C.96 Chi-Squared Test for Table C.95

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	21.105
df	18
Sig.	.274[a,b]

Results are based on nonempty rows and columns in each innermost subtable.

a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

b. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.97 ANOVA forTable C.95

ANOVA					
I learned from reading other people's problems, solutions and comments on grades.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.824	3	2.941	1.092	.353
Within Groups	719.316	267	2.694		
Total	728.140	270			

Table C.98 Homogeneity of Variance for Table C.97

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I learned from reading other people's problems, solutions and comments on grades.	Based on Mean	1.466	3	267	.224
	Based on Median	.804	3	267	.492
	Based on Median and with adjusted df	.804	3	249.431	.493
	Based on trimmed mean	1.240	3	267	.296

Table C.99 Tukey Test for Table C.97

Multiple Comparisons						
Dependent Variable: I learned from reading other people's problems, solutions and comments on grades.						
Tukey HSD						
(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Missing	Low	-.906	.533	.327	-2.28	.47
	Med	-.303	.418	.887	-1.38	.78
	High	-.405	.414	.762	-1.47	.66
Low	Missing	.906	.533	.327	-.47	2.28
	Med	.602	.400	.435	-.43	1.64
	High	.501	.395	.584	-.52	1.52
Med	Missing	.303	.418	.887	-.78	1.38
	Low	-.602	.400	.435	-1.64	.43
	High	-.102	.216	.965	-.66	.46
High	Missing	.405	.414	.762	-.66	1.47
	Low	-.501	.395	.584	-1.52	.52
	Med	.102	.216	.965	-.46	.66

Table C.100 Two-way ANOVA for Perceived Learning from Viewing Others by Course Type and GPA

Tests of Between-Subjects Effects					
Dependent Variable: I learned from reading other people's problems, solutions and comments on grades.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	33.053[a]	7	4.722	1.787	.090
Intercept	2164.241	1	2164.241	818.883	.000
GPA Level	7.940	3	2.647	1.001	.393
COURSETYPE	.470	1	.470	.178	.674
GPA Level * COURSETYPE	8.085	3	2.695	1.020	.384
Error	695.087	263	2.643		
Total	7022.000	271			
Corrected Total	728.140	270			

a. R Squared = .045 (Adjusted R Squared = .020)

Table C.101 Recommendation of the PL approach

I would recommend in the future that the PL approach be used for this course and its assignments.	1	N	32
		%	11.8
	2	N	22
		%	8.1
	3	N	41
		%	15.1
	4	N	54
		%	19.9
	5	N	48
		%	17.7
	6	N	42
		%	15.5
	7	N	32
		%	11.8
	Total	N	271
		Mean(Mn)	4.2
		Median(Md)	4
		Standard Deviation(Sd)	1.8

Table C.102 Recommendation of PL Approach Descriptive Statistics

Statistics		
I would recommend in the future that the PL approach be used for this course and its assignments.		
N	Valid	271
	Missing	0
Mean		4.17
Std. Error of Mean		.112
Median		4.00
Std. Deviation		1.839
Skewness		-.186
Std. Error of Skewness		.148
Kurtosis		-.931
Std. Error of Kurtosis		.295

Table C.103 Recommendation of PL Approach by Course Discipline, Course and GPA

	I would recommend in the future that the PL approach be used for this course and its assignments.											
	1	2	3	4	5	6	7	Total				
	%	%	%	%	%	%	%	Count	Mean	Median	Mode	SD
HUM	7.3	5.5	16.5	22.0	15.6	14.7	18.3	109	4.5	4	4	1.8
STEM	14.8	9.9	14.2	18.5	19.1	16.0	7.4	162	4.0	4	5	1.8
STEM 3	17.2	6.9	17.2	27.6	17.2	13.8	.0	29	3.6	4	4	1.6
STEM 4	28.1	12.5	12.5	12.5	15.6	18.8	.0	32	3.3	3	1	1.9
STEM 1	8.3	12.5	11.1	20.8	18.1	19.4	9.7	72	4.2	4	4	1.8
HUM 1	18.2	.0	27.3	27.3	.0	18.2	9.1	11	3.8	4	3[a]	1.9
HUM 2	5.7	8.6	22.9	25.7	20.0	11.4	5.7	35	4.0	4	4	1.5
HUM 4	7.7	11.5	11.5	30.8	11.5	7.7	19.2	26	4.3	4	4	1.9
STEM 2	13.8	3.4	20.7	10.3	27.6	6.9	17.2	29	4.2	5	5	1.9
HUM 3	5.4	.0	10.8	10.8	18.9	21.6	32.4	37	5.3	6	7	1.7
NOGPA	16.7	11.1	11.1	22.2	16.7	16.7	5.6	18	3.8	4	4	1.9
LOWGPA	10.0	.0	25.0	15.0	15.0	10.0	25.0	20	4.6	5	3[a]	2.0
MEDGPA	12.1	12.1	15.9	15.0	15.0	17.8	12.1	107	4.1	4	6	1.9
HIGHGPA	11.1	5.6	13.5	24.6	20.6	14.3	10.3	126	4.2	4	4	1.7

a. Multiple modes exist. The smallest value is shown

Table C.104 Recommendation of PL Approach by Course

		Course							
		STEM 3	STEM 4	STEM 1	HUM 1	HUM 2	HUM 4	STEM 2	HUM 3
1	N	5	9	6	2	2	2	4	2
	%	17.2	28.1	8.3	18.2	5.7	7.7	13.8	5.4
2	N	2	4	9	0	3	3	1	0
	%	6.9	12.5	12.5	.0	8.6	11.5	3.4	.0
3	N	5	4	8	3	8	3	6	4
	%	17.2	12.5	11.1	27.3	22.9	11.5	20.7	10.8
4	N	8	4	15	3	9	8	3	4
	%	27.6	12.5	20.8	27.3	25.7	30.8	10.3	10.8
5	N	5	5	13	0	7	3	8	7
	%	17.2	15.6	18.1	.0	20.0	11.5	27.6	18.9
6	N	4	6	14	2	4	2	2	8
	%	13.8	18.8	19.4	18.2	11.4	7.7	6.9	21.6
7	N	0	0	7	1	2	5	5	12
	%	.0	.0	9.7	9.1	5.7	19.2	17.2	32.4
Total	Count	29	32	72	11	35	26	29	37
	Mean	3.6	3.3	4.2	3.8	4.0	4.3	4.2	5.3
	Median	4	3	4	4	4	4	5	6
	Mode	4	1	4	3[a]	4	4	5	7
	SD	1.6	1.9	1.8	1.9	1.5	1.9	1.9	1.7

a. Multiple modes exist. The smallest value is shown

Table C.105 Chi-Squared Test for Table C.104

Pearson Chi-Square Tests	
	Course
Chi-square	64.228
df	42
Sig.	.015[*,b,c]

Results are based on nonempty rows and columns in each innermost subtable.

*. The Chi-square statistic is significant at the .05 level.

b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.106 ANOVA forTable C.104

ANOVA					
I would recommend in the future that the PL approach be used for this course and its assignments.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	84.504	7	12.072	3.833	.001
Within Groups	828.344	263	3.150		
Total	912.849	270			

Table C.107 Homogeneity of Variance for Table C.106

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I would recommend in the future that the PL approach be used for this course and its assignments.	Based on Mean	.924	7	263	.489
	Based on Median	.752	7	263	.628
	Based on Median and with adjusted df	.752	7	247.949	.628
	Based on trimmed mean	.927	7	263	.486

Table C.108a Tukey Test Part 1 for Table C.106

Multiple Comparisons						
Dependent Variable: I would recommend in the future that the PL approach be used for this course and its assignments.						
Tukey HSD						
		Mean			95% Confidence Interval	
		Difference	Std.		Lower	Upper
(I) Course	(J) Course	(I-J)	Error	Sig.	Bound	Bound
STEM 3	STEM 4	.308	.455	.998	-1.08	1.70
	STEM 1	-.629	.390	.743	-1.82	.56
	HUM 1	-.197	.628	1.000	-2.12	1.72
	HUM 2	-.408	.446	.984	-1.77	.95
	HUM 4	-.649	.479	.877	-2.11	.82
	STEM 2	-.621	.466	.886	-2.04	.80
	HUM 3	-1.704*	.440	.003	-3.05	-.36
STEM 4	STEM 3	-.308	.455	.998	-1.70	1.08
	STEM 1	-.937	.377	.206	-2.09	.21
	HUM 1	-.506	.620	.992	-2.40	1.39
	HUM 2	-.716	.434	.719	-2.04	.61
	HUM 4	-.957	.469	.456	-2.39	.48
	STEM 2	-.929	.455	.456	-2.32	.46
	HUM 3	-2.012*	.428	.000	-3.32	-.70
STEM 1	STEM 3	.629	.390	.743	-.56	1.82
	STEM 4	.938	.377	.206	-.21	2.09
	HUM 1	.432	.575	.995	-1.32	2.19
	HUM 2	.221	.366	.999	-.90	1.34
	HUM 4	-.019	.406	1.000	-1.26	1.22
	STEM 2	.009	.390	1.000	-1.18	1.20
	HUM 3	-1.074	.359	.060	-2.17	.02
HUM 1	STEM 3	.197	.628	1.000	-1.72	2.12
	STEM 4	.506	.620	.992	-1.39	2.40
	STEM 1	-.432	.575	.995	-2.19	1.32
	HUM 2	-.210	.613	1.000	-2.08	1.66
	HUM 4	-.451	.638	.997	-2.40	1.50
	STEM 2	-.423	.628	.998	-2.34	1.50
	HUM 3	-1.506	.609	.213	-3.37	.36

*. The mean difference is significant at the 0.05 level.

Table C.108b Tukey Test Part 2 for Table C.106

Multiple Comparisons						
Dependent Variable: I would recommend in the future that the PL approach be used for this course and its assignments.						
Tukey HSD						
		Mean			95% Confidence Interval	
(I) Course	(J) Course	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
HUM 2	STEM 3	.408	.446	.984	-.95	1.77
	STEM 4	.716	.434	.719	-.61	2.04
	STEM 1	-.221	.366	.999	-1.34	.90
	HUM 1	.210	.613	1.000	-1.66	2.08
	HUM 4	-.241	.459	1.000	-1.64	1.16
	STEM 2	-.213	.446	1.000	-1.57	1.15
	HUM 3	-1.296*	.418	.044	-2.57	-.02
HUM 4	STEM 3	.649	.479	.877	-.82	2.11
	STEM 4	.957	.469	.456	-.48	2.39
	STEM 1	.019	.406	1.000	-1.22	1.26
	HUM 1	.451	.638	.997	-1.50	2.40
	HUM 2	.241	.459	1.000	-1.16	1.64
	STEM 2	.028	.479	1.000	-1.44	1.49
	HUM 3	-1.055	.454	.285	-2.44	.33
STEM 2	STEM 3	.621	.466	.886	-.80	2.04
	STEM 4	.929	.455	.456	-.46	2.32
	STEM 1	-.009	.390	1.000	-1.20	1.18
	HUM 1	.423	.628	.998	-1.50	2.34
	HUM 2	.213	.446	1.000	-1.15	1.57
	HUM 4	-.028	.479	1.000	-1.49	1.44
	HUM 3	-1.083	.440	.217	-2.43	.26
HUM 3	STEM 3	1.704*	.440	.003	.36	3.05
	STEM 4	2.012*	.428	.000	.70	3.32
	STEM 1	1.074	.359	.060	-.02	2.17
	HUM 1	1.506	.609	.213	-.36	3.37
	HUM 2	1.296*	.418	.044	.02	2.57
	HUM 4	1.055	.454	.285	-.33	2.44
	STEM 2	1.083	.440	.217	-.26	2.43

*. The mean difference is significant at the 0.05 level.

Table C.109 Recommendation of PL Approach by GPA

		GPA LEVEL			
		Missing	Low	Med	High
1	N	3	2	13	14
	%	16.7	10.0	12.1	11.1
2	N	2	0	13	7
	%	11.1	.0	12.1	5.6
3	N	2	5	17	17
	%	11.1	25.0	15.9	13.5
4	N	4	3	16	31
	%	22.2	15.0	15.0	24.6
5	N	3	3	16	26
	%	16.7	15.0	15.0	20.6
6	N	3	2	19	18
	%	16.7	10.0	17.8	14.3
7	N	1	5	13	13
	%	5.6	25.0	12.1	10.3
Total	Count	18	20	107	126
	Mean	3.8	4.6	4.1	4.2
	Median	4	5	4	4
	Mode	4	3[a]	6	4
	SD	1.9	2.0	1.9	1.7

a. Multiple modes exist. The smallest value is shown

Table C.110 Chi-Squared Test for Table C.109

Pearson Chi-Square Tests	
	GPA LEVEL
Chi-square	16.038
df	18
Sig.	.590[a]

Results are based on nonempty rows and columns in each innermost subtable.

a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

Table C.111 ANOVA for Table C.109

ANOVA					
I would recommend in the future that the PL approach be used for this course and its assignments.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.752	3	1.917	.564	.639
Within Groups	907.097	267	3.397		
Total	912.849	270			

Table C.112 Homogeneity of Variance for Table C.111

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
I would recommend in the future that the PL approach be used for this course and its assignments.	Based on Mean	1.237	3	267	.297
	Based on Median	1.267	3	267	.286
	Based on Median and with adjusted df	1.267	3	265.685	.286
	Based on trimmed mean	1.229	3	267	.299

Table C.113 Tukey Test for Table C.111

Multiple Comparisons						
Dependent Variable: I would recommend in the future that the PL approach be used for this course and its assignments.						
Tukey HSD						
(I) GPA LEVEL	(J) GPA LEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Missing	Low	-.717	.599	.629	-2.26	.83
	Med	-.269	.470	.940	-1.48	.94
	High	-.389	.464	.837	-1.59	.81
Low	Missing	.717	.599	.629	-.83	2.26
	Med	.447	.449	.752	-.71	1.61
	High	.328	.444	.881	-.82	1.47
Med	Missing	.269	.470	.940	-.94	1.48
	Low	-.447	.449	.752	-1.61	.71
	High	-.119	.242	.961	-.75	.51
High	Missing	.389	.464	.837	-.81	1.59
	Low	-.328	.444	.881	-1.47	.82
	Med	.119	.242	.961	-.51	.75

Table C.114 Two-way ANOVA for Recommendation of PL by Course Type and GPA

Tests of Between-Subjects Effects					
Dependent Variable: I would recommend in the future that the PL approach be used for this course and its assignments.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35.160[a]	7	5.023	1.505	.166
Intercept	1466.717	1	1466.717	439.503	.000
GPA Level	6.461	3	2.154	.645	.586
COURSE TYPE	11.872	1	11.872	3.558	.060
GPA Level * COURSE TYPE	11.177	3	3.726	1.116	.343
Error	877.688	263	3.337		
Total	5633.000	271			
Corrected Total	912.849	270			

a. R Squared = .039 (Adjusted R Squared = .013)

Table C.115 Inter-Construct Correlation (Main Study)

Inter-Construct Correlation (Fornell-Larcker criterion)										
			Inter-Construct Correlations							
Mean	SD	Construct	AL	AU	EE	FC	PE	PLe	PO	RU
60.79	29.6	AL	1							
1.81	0.9	AU	0.26	1						
4.48	1.4	EE	-0.01	0.05	1					
5.22	1.3	FC	-0.16	-0.05	-0.21	0.85				
5.61	1.5	PE	-0.1	0.1	-0.17	0.77	0.77			
5.98	1.5	PLe	-0.03	0.07	-0.17	0.72	0.83	0.79		
80.13	29	PO	0.19	0.43	0.04	0.01	0.12	0.1	1	
4.21	1.8	RU	-0.09	0.14	-0.14	0.57	0.81	0.71	0.1	1

Construct Legend: Actual Learning (AL), Actual Use (AU), Effort Expectancy (EE), Facilitating Conditions (FC), Perceived Enjoyment (PE), Perceived Learning (PL), Performance Outcome (PO), Recommendation For Use (R)
According to Fornell-Larcker, for adequate discriminant validity, diagonal elements should be greater than corresponding off-diagonal. In the diagonal we present the square root of AVE. [92], [93]

Table C.116a PLS Factor Analysis (Main Study) Part 1

PLS Factor Analysis				
	Mean	Std. Deviation	Item Loading	Std. Error
Actual Learning				
CR = 1.00 AVE= 1.00				
Critical Thinking Question Score	60.793	29.616	1	0
Actual Use				
CR = 1.00 AVE= 1.00				
#Of Assignments Completed	1.807	0.935	1	0
Effort Expectancy				
CR = 1.00 AVE= 1.00				
How easy/difficult do you find this course is?	4.48	1.424	1	0
Facilitating Conditions				
CR = 0.89 AVE= 0.73				
The *problem & solution guidelines* given by the instructor are explicit enough.	5.291	1.455	0.84	0.023
I felt the grading process was fair.	5.260	1.469	0.83	0.024
The instructor coordinated the PL approach well.	5.118	1.651	0.89	0.014
Perceived Enjoyment				
CR = 0.88 AVE=0.6				
I enjoyed the flexibility that the PL approach allowed in organizing my resources.	5.314	1.662	0.86	0.019
The time allowed for the PL assignments was sufficient.	5.334	1.518	0.71	0.035
During this course, I was motivated to do my best work	5.243	1.594	0.74	0.03
I enjoyed the PL approach.	4.324	1.822	0.86	0.015
System Usability Scale	0.785		0.68	0.041

CR = Composite Reliability; AVE: Average Variance Extracted, SD: Standard Deviation
Construct Scale: Actual learning (AL) and Performance Outcome (PO) are from 0 – 100; Actual Use (AU) is from 0 to 3; Effort Expectancy: (Easy) 1-7 (Difficult); CAP Cognitive and CAP affective is from 0 to 18; Facilitating Conditions, Perceived Enjoyment and Perceived Learning are from (Strongly Agree) 1 – 7 (Strongly Disagree).

Table C.116b PLS Factor Analysis (Main Study) Part 2

PLS Factor Analysis				
	Mean	Std. Deviation	Item Loading	Std. Error
Perceived Learning				
CR = 0.91 AVE=0.62				
Overall, I learned a lot in this course.	5.459	1.49	0.79	0.026
I learned from having to make up problems.	4.858	1.566	0.74	0.037
I learned from solving problems with the PL approach.	4.578	1.636	0.87	0.015
I learned from grading other students' solutions.	4.574	1.723	0.82	0.024
CAP Cognitive	11.274	3.410	0.79	0.037
CAP Affective	11.682	3.817	0.79	0.031
Performance Outcome				
CR = 1.00 AVE= 1.00				
PL Score	80.13	29.021	1	0
Recommendation of Use				
CR = 1.00 AVE= 1.00				
Would you recommend in the future that the PL approach be used for this course and its assignments?	4.206	1.822	1	0

CR = Composite Reliability; AVE: Average Variance Extracted, SD: Standard Deviation
Construct Scale: Actual learning (AL) and Performance Outcome (PO) are from 0 – 100; Actual Use (AU) is from 0 to 3; Effort Expectancy: (Easy) 1-7 (Difficult); CAP Cognitive and CAP affective is from 0 to 18; Facilitating Conditions, Perceived Enjoyment and Perceived Learning are from (Strongly Agree) 1 – 7 (Strongly Disagree).

Table C.117 Inter-Construct Statistics (Main Study)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Actual Use -> Actual Learning	0.272	0.269	0.068	4.018	0
Actual Use Mod -> Actual Learning	-0.224	-0.241	0.069	3.239	0.001
Effort Expectancy -> Perceived Enjoyment	-0.011	-0.011	0.042	0.264	0.792
Effort Expectancy -> Performance Outcome	0.042	0.044	0.065	0.649	0.517
Facilitating Conditions -> Perceived Enjoyment	0.762	0.761	0.028	27.592	0
Facilitating Conditions -> Perceived Learning	0.205	0.21	0.06	3.425	0.001
Perceived Enjoyment -> Perceived Learning	0.674	0.672	0.056	12.141	0
Perceived Enjoyment -> Recommendation For Use	0.719	0.718	0.074	9.717	0
Perceived Learning -> Actual Learning	-0.034	-0.035	0.07	0.491	0.623
Perceived Learning -> Recommendation For Use	0.108	0.109	0.086	1.258	0.209
Performance Outcome -> Perceived Enjoyment	0.106	0.105	0.04	2.62	0.009

Table C.118 Multi Group Path Coefficient

	Path Coefficients Regular	Path Coefficient Micro	p-Value Regular	p-Value Micro
Effort Expectancy -> Perceived Enjoyment	-0.097	0.028	0.247	0.835
Effort Expectancy -> Performance Outcome	-0.211	0.145	0.279	0.564
Facilitating Conditions -> Perceived Enjoyment	0.771	0.817	0	0
Facilitating Conditions -> Perceived Learning	0.706	0.555	0	0.001
Perceived Enjoyment -> Perceived Learning	0.255	0.342	0.123	0.052
Perceived Enjoyment -> Recommendation For Use	0.609	0.191	0.005	0.341
Perceived Learning -> Actual Learning	-0.118	0.276	0.501	0.173
Perceived Learning -> Recommendation For Use	0.313	0.658	0.156	0
Performance Outcome -> Perceived Enjoyment	0.18	-0.11	0.049	0.311

Table C.119 Multi Group Path Coefficient

	Path Coefficients-diff (Regular - Micro)	t-Value(Regular - Micro)	p-Value (Regular - Micro)
EffortExpectancy -> PerceivedEnjoyment	-0.125	0.83	0.41
EffortExpectancy -> PerformanceOutcome	-0.356	1.157	0.253
FacilitatingConditions -> PerceivedEnjoyment	-0.046	0.488	0.628
FacilitatingConditions -> PerceivedLearning	0.151	0.651	0.518
PerceivedEnjoyment -> PerceivedLearning	-0.086	0.364	0.717
PerceivedEnjoyment -> RecommendationForUse	0.418	1.418	0.162
PerceivedLearning -> ActualLearning	-0.394	1.508	0.138
PerceivedLearning -> RecommendationForUse	-0.345	1.208	0.232
PerformanceOutcome -> PerceivedEnjoyment	0.29	2.098	0.041

Table C.120 Enjoyment and Motivation Results Part 1

			Condition	
			Control	Treatment
Overall, I was motivated in this course.	1	%	5.7%	6.2%
	2	%	8.1%	6.2%
	3	%	10.0%	6.2%
	4	%	10.5%	18.5%
	5	%	21.0%	22.8%
	6	%	24.3%	23.5%
	7	%	20.5%	16.7%
	Total	Mean	4.88	4.83
		Med	5	5
		SD	1.79	1.69
Overall, I enjoyed this course.	1	%	9.0%	5.6%
	2	%	3.3%	6.8%
	3	%	8.1%	5.6%
	4	%	12.4%	20.4%
	5	%	17.1%	24.1%
	6	%	21.9%	21.6%
	7	%	28.1%	16.0%
	Total	Mean	5.03	4.80
		Med	6	5
		SD	1.89	1.66

Table C.121 Enjoyment and Motivation Results Part 2

Pearson Chi-Square Tests		
		Condition
Overall, I was motivated in this course.	Chi-square	7.218
	df	6
	Sig.	.301
Overall, I enjoyed this course.	Chi-square	16.255
	df	6
	Sig.	.012*

Results are based on nonempty rows and columns in each innermost subtable.
*. The Chi-square statistic is significant at the .05 level.

Table C.122 Enjoyment and Motivation Results Part 3

Independent Samples Test							
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Overall, I enjoyed this course.	Equal variances assumed	3.387	0.067	1.266	370	0.206
	Equal variances not assumed			1.286	363.46	0.199
Overall, I was motivated in this course.	Equal variances assumed	1.149	0.284	0.268	370	0.789
	Equal variances not assumed			0.270	355.19	0.787

Table C.123 Motivation Results by Course

		Overall, I was motivated in this course.									
		1	2	3	4	5	6	7	Total		
		%	%	%	%	%	%	%	Mean	Median	SD
STEM 3	Control	15.8	17.5	14.0	12.3	12.3	15.8	12.3	3.8	4	2.0
	Treatment	6.9	3.4	10.3	27.6	24.1	13.8	13.8	4.6	5	1.6
STEM 4	Control	3.4	8.5	11.9	15.3	28.8	18.6	13.6	4.7	5	1.6
	Treatment	12.5	12.5	6.3	15.6	18.8	21.9	12.5	4.3	5	2.0
HUM 1	Control	.0	3.3	.0	3.3	20.0	36.7	36.7	6.0	6	1.1
	Treatment	9.1	9.1	.0	.0	36.4	27.3	18.2	5.0	5	1.9
HUM 2	Control	.0	.0	9.1	.0	27.3	9.1	54.5	6.0	7	1.3
	Treatment	.0	5.7	8.6	25.7	28.6	22.9	8.6	4.8	5	1.3
HUM 4	Control	.0	3.6	10.7	7.1	14.3	35.7	28.6	5.5	6	1.5
	Treatment	.0	.0	3.8	15.4	11.5	38.5	30.8	5.8	6	1.2
STEM 2	Control	4.0	.0	8.0	12.0	28.0	36.0	12.0	5.2	5	1.4
	Treatment	10.3	6.9	3.4	13.8	24.1	20.7	20.7	4.8	5	1.9

Table C.124 Motivation Results Test

Pearson Chi-Square Tests				
				Overall, I was motivated in this course.
Course	STEM 4	Condition	Chi-square	8.705
			df	6
			Sig.	.191[a]
	STEM 3	Condition	Chi-square	4.573
			df	6
			Sig.	.600[a]
	HUM 1	Condition	Chi-square	5.600
			df	5
			Sig.	.347[a,b]
	HUM 2	Condition	Chi-square	13.317
			df	5
			Sig.	.021[a,b,*]
	HUM 4	Condition	Chi-square	2.739
			df	5
			Sig.	.740[a,b]
	STEM 2	Condition	Chi-square	4.806
			df	6
			Sig.	.569[a,b]

Results are based on nonempty rows and columns in each innermost subtable.

*. The Chi-square statistic is significant at the .05 level.

a. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.

b. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.125 Motivation by GPA and Condition

			Overall, I was motivated in this course.									
			1	2	3	4	5	6	7	Total		
			%	%	%	%	%	%	%	Mean	Median	SD
GPA LEVEL	Low GPA	Control	3.7	.0	.0	.0	22.2	29.6	44.4	6.0	6	1.3
		Treatment	.0	10.0	.0	30.0	30.0	20.0	10.0	4.8	5	1.4
	Med GPA	Control	4.5	11.9	10.4	16.4	23.9	22.4	10.4	4.5	5	1.7
		Treatment	8.9	5.4	3.6	19.6	25.0	19.6	17.9	4.8	5	1.8
	No GPA	Control	.0	.0	4.0	12.0	16.0	36.0	32.0	5.8	6	1.2
		Treatment	5.6	11.1	.0	5.6	33.3	27.8	16.7	5.0	5	1.7
	Top GPA	Control	8.8	9.9	14.3	8.8	19.8	20.9	17.6	4.5	5	1.9
		Treatment	5.1	5.1	10.3	19.2	17.9	25.6	16.7	4.8	5	1.7

Table C.126 Motivation by GPA and Treatment Test

Pearson Chi-Square Tests

			Overall, I was motivated in this course.
GPA LEVEL	Low GPA	Chi-square	14.066
		df	5
		Sig.	.015*,b,c
	Med GPA	Chi-square	5.892
		df	6
		Sig.	.435b
	No GPA	Chi-square	7.885
		df	6
		Sig.	.247b,c
	Top GPA	Chi-square	6.451
		df	6
		Sig.	.375

Results are based on nonempty rows and columns in each innermost subtable.
*. The Chi-square statistic is significant at the .05 level.
b. More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.
c. The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.

Table C.127 Learning Perception by Course

		Overall, I learn a lot in this course.									
		1	2	3	4	5	6	7	Total		
		%	%	%	%	%	%	%	Mean	Median	SD
STEM 3	Control	13.0	7.4	9.3	24.1	14.8	18.5	13.0	4.3	4	1.9
	Treatment	4.0	4.0	4.0	20.0	36.0	28.0	4.0	4.8	5	1.4
STEM 4	Control	.0	2.3	4.7	14.0	34.9	18.6	25.6	5.4	5	1.3
	Treatment	3.7	3.7	7.4	18.5	29.6	25.9	11.1	4.9	5	1.5
HUM 1	Control	.0	.0	.0	10.5	26.3	26.3	36.8	5.9	6	1.0
	Treatment	11.1	11.1	11.1	.0	.0	44.4	22.2	4.9	6	2.3
HUM 2	Control	12.5	.0	12.5	12.5	12.5	25.0	25.0	4.9	6	2.1
	Treatment	9.7	.0	9.7	22.6	32.3	16.1	9.7	4.5	5	1.6
HUM 4	Control	.0	4.2	4.2	20.8	8.3	37.5	25.0	5.5	6	1.4
	Treatment	.0	.0	.0	6.7	20.0	33.3	40.0	6.1	6	1.0
STEM 2	Control	.0	4.5	9.1	9.1	31.8	31.8	13.6	5.2	5	1.3
	Treatment	.0	3.8	11.5	15.4	19.2	26.9	23.1	5.2	6	1.5

Table C.128 Overall Learning Perception

			Control	**Treatment**
Overall, I learned a lot in this course.	1	N%	4.3%	2.5%
	2	N%	3.3%	3.1%
	3	N%	5.7%	7.4%
	4	N%	13.8%	16.0%
	5	N%	19.0%	26.5%
	6	N%	24.3%	25.9%
	7	N%	29.5%	18.5%
	Total	N	210	162
		Mean	5.3	5.1
		Med	6	5
		SD	1.6	1.5

Table C.129 Overall Learning Perception T-Test

Independent Samples Test							
		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)
Overall, I learned a lot in this course.	Equal variances assumed	3.802	0.052	1.100	370	0.272
	Equal variances not assumed			1.117	362.643	0.265

Table C.130 Critical Thinking by Course

		Count	Mean	Median	Standard Deviation
STEM 3	Control	57	29	30.0	14.7
	Treatment	29	24	30.0	12.1
STEM 4	Control	59	82	94.0	30.8
	Treatment	32	90	94.0	17.9
HUM 1	Control	30	71	70.8	12.4
	Treatment	11	63	63.3	.
HUM 2	Control	11	57	61.7	27.0
	Treatment	35	69	73.3	19.6
HUM 4	Control	28	77	75.0	6.0
	Treatment	26	69	69.2	8.2
STEM 2	Control	25	60	65.0	19.7
	Treatment	29	71	80.0	28.3

Table C.131 Overall Critical Thinking Descriptive Statistics

Group Statistics					
	Condition	N	Mean	Std. Deviation	Std. Error Mean
CRITICAL THINKING	Control	159	57.87	32.59	2.58
	Treatment	126	64.52	30.80	2.74

Table C.132 Critical Thinking Significance Results

Independent Samples Test						
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
CRITICAL THINKING	Equal variances assumed	2.048	0.153	-1.754	283	0.081
	Equal variances not assumed			-1.765	274.336	0.079

Table C.133 Two-way ANOVA for Critical Thinking, Condition and Course Type

Tests of Between-Subjects Effects					
Dependent Variable: CRITICAL THINKING					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5133.359[a]	3	1711.120	1.691	.169
Intercept	633307.204	1	633307.204	625.691	.000
Condition	981.098	1	981.098	.969	.326
COURSE TYPE	1984.672	1	1984.672	1.961	.163
Condition* COURSE TYPE	21.061	1	21.061	.021	.885
Error	284420.674	281	1012.173		
Total	1343582.889	285			
Corrected Total	289554.033	284			

Table C.134 Microlearning Questions Descriptive Statistics

		Count	%	Mean	Median	SD
I enjoyed that the PL stages (creating, solving, grading) were broken into multiple parts.	2	1	4%			
	4	3	12%			
	5	6	24%			
	6	7	28%			
	7	8	32%			
	Total	25		5.7	6	1.3
I believe breaking down the PL stages into multiple parts was clearly explained.	2	3	12%			
	4	4	16%			
	5	8	32%			
	6	8	32%			
	7	2	8%			
	Total	25		5.0	5	1.4
Breaking down the PL stages into parts helps me have enough time to finish each task.	3	3	12%			
	4	3	12%			
	5	7	28%			
	6	7	28%			
	7	5	20%			
	Total	25		5.3	5	1.3
It felt that breaking down the PL stages into parts added unnecessary extra work.	1	3	12%			
	2	3	12%			
	3	7	28%			
	4	5	20%			
	5	4	16%			
	6	3	12%			
	Total	25		3.5	3	1.5

APPENDIX D

PL ASSIGNMENT WORK

In this Appendix D, a regular assignment and PL assignment as shown for comparison purposes. In addition, guidelines on how to convert the assignment is provided.

D.1 Converting Regular to PL Assignments

In Appendix D.1 and D.2 I present examples of a regular and a PL assignment. In this section, I will present general guidelines on how to approach the conversion of traditional assignments to PL assignments.

1. The first step to convert an assignment to a PL form is deciding the type of assignment that students will be part of. Some assignments are very straight forward where an instructor selects a topic, and the students are in charge of coming up with questions, solving and grading each other. However, there are other assignments that are more involved in which the student can participate at multiple stages of the assignment repeatedly.

2. Once the type of assignment is decided, the next step is to decide whether students can actually participate in all stages of the assignment. For example, if the assignment is about a math chapter covered in class, students could come up with math questions to ask each other. The topic itself is very focused and thus while the questions can be very complex, most of the time they would be focused around specific ideas covered in class. However, there will be times when it will be difficult have a student make a problem to other such as in the case of an essay draft. While it would certainly be an interesting experiment to have someone choose a topic for someone else, usually students like to decide their own topics as they do have some prior knowledge or preference on what they will write about.

3. The next step is to determine the amount of instructions to give the student (if they have been asked to create a problem). There is a delicate balance to strike when giving enough instructions to students to guide how they should be asking a question against providing guidance that is too detail or specific that it would stiffen the creativity of students.

4. After problem creation and before solving a problem, there is usually an opportunity for quality control that could be added if the instructor believes students would struggle creating question. Problem creation quality control task are achieved by 1) assigning a feedback loop between instructor and student where a problem does not get approved and sent to another student unless the instructor

determines is good enough, or 2) the revision problem is done by another student who can either approve the question or simply provide feedback for the problem creator to consider.

5. In addition, is important to create a set of solution instructions that would provide general guidelines on what an ideal solution would include. These guidelines would ideally include a rubric for grading so that students know how their work will be evaluated.

6. It will also be important to create clear guidelines on how to evaluate others work. This can be achieved by providing a specific set of criterion on what aspects to grade and a scoring sheet representing what is considered a full mark, a zero and grades in between.

7. The final step would be to decide whether a student can dispute their grade. Usually, when this option is selected, a very few number of students end up disputing their grade. In this case, providing clear guidelines on what is the minimum percentage to dispute would also help reducing the dispute number by preventing students from dispute 1 or 2 extra points. However, this should be decided in advance and clearly communicated to the students.

Overall, to convert a regular assignment to the PL approach, it's important to determine the type of assignment, and the degree of student interaction wanted. Once it is determined what tasks students will be responsible for, providing clear guidelines is important to help guide the process.

D.2 Example Regular Assignment

ER Diagram Assignment

University DB Example

Consider the following set of requirements for a university database that is used to keep track of students' transcripts.

(a) The university keeps track of each student's name, student number, social security number, current address and phone, permanent address and phone, birth date, gender, class (freshman, sophomore, ..., graduate), major department, minor department (if any), and degree program (B.A., B.S., ..., Ph.D.). Some user applications need to refer to the city, state, and zip of the student's permanent address, and to the student's last name. Both social security number and student number have unique values for each student.

(b) Each department is described by a name, department code, office number, office phone, and college. Both name and code have unique values for each department.

(c) Each course has a course name, description, course number, number of semester hours, level, and offering department. The value of course number is unique for each course.

(d) Each section has an instructor, semester, year, course, and section number. The section number distinguishes different sections of the same course that are taught during the same semester/year; its values are 1, 2, 3, ...; up to the number of sections taught during each semester.

(e) A grade report has a student, section, letter grade, and numeric grade (0, 1, 2, 3, 4 for F, D, C, B, A, respectively).

Design an ER schema for this application, and draw an ER diagram for that schema. Specify key attributes of each entity type and structural constraints on each relationship type. Note any unspecified requirements, and make appropriate assumptions to make the specification complete.

D.3 Example PL Assignment

PL Assignment ER DIAGRAM

General Information

For this assignment, you will create a set of business rules (or requirements) for a database. Another student will use these business rules and design an ER schema and draw an ER diagram. Two other students will grade the ER diagram (you will not grade your own diagram) and a third student will act as the grade consolidator in case the grades from the original two grades differ by a significant margin. At the end, you will get the chance to review and dispute your grade if desired.

Task 1: Create Business Rules (Due: 02/16/2021)

You will create a set of requirements for capturing data for an application. Your requirements should be complete and allow others to be able to create an ER schema and an ER diagram.

Your specifications should contain:

1. At least 5 entities each with 5 or more attributes.
2. 3-4 binary relationships among entities (additional unary relationships are optional).

Please name your MS-Word file the following: "business_rules"

Example:*(Your business rules must be different from these, this is just an example)*

> *(a) The university keeps track of each student's name, student number, social security number, current address and phone, permanent address and phone, birth date, gender, class (freshman, sophomore, ..., graduate), major department, minor department (if any), and degree program (B.A., B.S., ..., Ph.D.). Some user applications need to refer to the city, state, and zip of the student's permanent address, and to the student's last name. Both social security number and student number have unique values for each student.*
>
> *(b) Each department is described by a name, department code, office number, office phone, and college. Both name and code have unique values for each department.*
>
> *(c) Each course has a course name, description, course number, number of semester hours, level, and offering department. The value of course number is unique for each course.*
>
> *(d) Each section has an instructor, semester, year, course, and section number. The section number distinguishes different sections of the same course that are taught during the same semester/year; its values are 1, 2, 3, ...; up to the number of sections taught during each semester.*
>
> *(e) A grade report has a student, section, letter grade, and numeric grade (0, 1, 2, 3, 4 for F, D, C, B, A, respectively).*

Task 2: Approve Business Rules (Due: 02/20/2021)

The TA will review your initial business requirements and do the following:

a) Approve the business rules and send it to another student for solving.

b) Reject the business rules and send them back to its creator for revision along with suggestions for improvement. This is an iterative process.

Note, the business rules must be *approved* by 02/19/2021 but will be reviewed soon after *your submission* on the 02/16/2021. The TA will work on approving or rejecting them. If your work is rejected, you will have until 02/12/2021 to resubmit and have it approved. Please fix any issues with your business_rules document before the deadline.

Task 3: Solve ER diagram (Due: 02/26/2021)

Create an ER schema and an ER diagram based on the business rules created by another student. Your diagrams should specify key attributes of each entity type and structural constraints on each relationship type. Note any unspecified requirements, and make appropriate assumptions to make the specification complete.

Note: You WILL NOT create diagrams based on the business rules you developed yourself; instead, you will solve the ER diagram created by another student based on the business rules they created.

Please name your MS-Word or Visio file the following: "er_diagram"

Task 4: Grade ER diagram (Due: 03/1/2021)

You will grade another two students' diagrams. To grade their diagrams, you will download the business rules from Task 1: "Create Business Rules", and the ER diagram from Task 2: "Solve ER diagram" (Important Note: remember to scroll up on the Participatory Learning website task page.)

You will grade the diagrams based on the following criteria:

	10 points	**8 points**	**6 points**	**4 points**	**2 points**	**0 points**
# of Entities	5 entities	4 entities	3 entities	2 entities	1 entities	0 entities
# of attributes	5 attributes	4 attributes	3 attributes	n/a	n/a	2 or less attributes
# of relationships	4 relations	3 relations	n/a	n/a	n/a	2 or less relations
Cardinalities	Yes	n/a	n/a	n/a	n/a	No
Participation constraints	Yes	n/a	n/a	n/a	n/a	No

You will not grade your own diagram.

Task 5: Consolidate the ER Diagram grades (Due: 03/04/2021)

In special circumstances, you will consolidate two other grades given by students into a single fair representation. To provide this grade, you will download the business rules from Task 1, and the ER diagram from Task 2 (remember to scroll up on the Participatory Learning website) while also reviewing the notes given by the first and second graders.

Your grade will be the final grade the student receives for this assignment. You will grade the diagrams based on the following criteria:

	10 points	**8 points**	**6 points**	**4 points**	**2 points**	**0 points**
# of Entities	5 entities	4 entities	3 entities	2 entities	1 entities	0 entities
# of attributes	5 attributes	4 attributes	3 attributes	n/a	n/a	2 or less attributes
# of relationships	4 relations	3 relations	n/a	n/a	n/a	2 or less relations
Cardinalities	Yes	n/a	n/a	n/a	n/a	No
Participation constraints	Yes	n/a	n/a	n/a	n/a	No

Task 6: Dispute Grade (Optional) (Due: 03/07/2021)

Your final grade will be determined as follows:

a) If you only have received two grades, your grade will be the higher of the two grades.

b) If you have a third grader, your final grade will be the grade given by this person (the grade consolidator)

After reviewing your assignment grade, you have the option to dispute this grade with the professor if you believe you deserve a higher grade.

To dispute your grade, you will grade your own work (your diagrams) using the following criteria, and also justify why the other graders were wrong.

	10 points	**8 points**	**6 points**	**4 points**	**2 points**	**0 points**
# of Entities	5 entities	4 entities	3 entities	2 entities	1 entities	0 entities
# of attributes	5 attributes	4 attributes	3 attributes	n/a	n/a	2 or less attributes
# of relationships	4 relations	3 relations	n/a	n/a	n/a	2 or less relations
Cardinalities	Yes	n/a	n/a	n/a	n/a	No
Participation constraints	Yes	n/a	n/a	n/a	n/a	No

Task 7: Resolve Grade Dispute

The Professor will review your grade dispute and provide you with a final grade for the assignment.

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