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Students' Perceptions of Tablet-Enhanced Learning Environment on the Development of Communication and Critical Thinking Skills: An Interdisciplinary Study

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Abstract

The ubiquitous presence of social media and recent advancement in mobile computing has been reshaping the higher education technology landscape, which leads to a more competency-based, learner-centered, and technology-driven learning environment. In response to this paradigm shift, Fresno State recently launched its tablet program called DISCOVERe as an aggressive initiative to break down the digital divide and explore new ways of teaching and learning. Selected course sections are offered as tablet only courses. These courses have been redesigned to provide students an enhanced learning experience.

One of the most significant learning behavior transformations in a tablet-enhanced learning environment is the active collaboration and interaction among students and instructors in class activities and course projects. In this context, how we practice communication and critical thinking may change to accommodate new formats and purposes facilitated by technology. However, at this early phase of the DISCOVERe tablet program, it remains unclear to instructors what pedagogical approaches and curriculum designs are most effective to cultivate these two critical skills and prepare students for their academic and professional careers. In this interdisciplinary study, the researchers selected three tablet courses (i.e. Construction Graphics, Green Building Design and Delivery, and Administration of Personnel) from engineering and business management curricula. Project-based learning and flipped classroom pedagogies were adopted in all three courses. Direct and indirect measures, along with associated rubrics were developed to assess the targeted student learning outcomes: (1) oral/written/graphical communication, and (2) critical thinking, in a tablet-enhanced learning environment with an emphasis on active and collaborative learning. This paper discusses students' perceptions of the impact of the Tablet PC on engineering and business management education and provides recommendations on practical pedagogies and assessment strategies.

Introduction

Information and communications technology (ICT) has been playing an essential role in communication and critical thinking and is widely used in today's education field. As a powerful tool for educational change and reform, ICT is expected to support students in exploring and articulating thoughts, knowledge construction and theory building [1], enabling collaborative learning in a distance-learning environment [2], and developing critical (higher-order) thinking skills [3] [4] [5]. Researchers [5] [6] [7] [8] [9] suggest that by fostering autonomy, capability, and creativity for educators and students, ICT can ultimately improve the quality of teaching and learning.

As a portable format of a computer, the Tablet PC is now showing a rapid increase in campus use due to its many desirable features ranging from a large collection of tools, to eBooks and digital textbooks, to interactive learning networks and instant feedback. Compared to traditional computing devices, its distinguishing features include a high mobility, a low proneness for software problems, and an instant usability [10]. The tablet-enabled learning environment introduces many changes to modern teaching and learning. One of the most significant learning behavior transformations is the active collaboration among students in class activities and course projects [11] [12] [13]. Numerous earlier studies have concurred that collaborative learning fosters the development of critical thinking and problem-solving skills through discussions, clarification of ideas, and evaluation of others' ideas [14] [15] [16] [17] [18]. Little research has been conducted, however, to examine the relationship between a tablet-enhanced collaborative learning environment and the development of students' oral, written, or graphical communication skills.

The goal of this interdisciplinary study was to explore effective pedagogical approaches and curriculum designs to cultivate the following set essential skills: (1) oral/written/graphical communication, and (2) critical thinking, in a tablet-enhanced learning environment with an emphasis on active and collaborative learning. The researchers selected three tablet courses from engineering and business management curricula as the two skills are considered core competencies for students from both disciplines in pursuit of academic and professional excellence. This paper will mainly discuss students' perceptions as a means to understand and improve the usage of the Tablet PC.

Background

An aggressive initiative to break down the digital divide and rethink educating tomorrow's leaders, the DISCOVERe tablet program at Fresno State was officially launched in spring 2014. It's anticipated to involve a total of 5000 students and 150 faculty members by the end of 2015-2016 AY. DISCOVERe courses are designed and offered as tablet only courses. Students may use iOS-, Android-, or Windows-based tablets (if they meet specifications). Accompanying the tablet program are vigorous administrative and technical support to faculty and students, along with significant investments in upgrading existing learning management systems and subscribing to a wide collection of learning solutions and instructional resources, all of which help form a healthy and sustainable digital learning ecosystem. The goal is beyond technology, however, but to create a new educational paradigm that leverages digital learning solutions to strengthen student engagement, foster academic success, and improve quality assurance of institutional effectiveness.

Three Fall 2015 DISCOVERe courses from two disciplines (i.e. Construction Management and Business Management) were selected for this study. They were **CM4**: Construction Graphics, **CM177**: Green Building Design and Delivery, and **HRM150**: Administration of Personnel.

CM4 is a lower division core course for Construction Management students. It introduces fundamentals and techniques of graphic communication in the construction industry. Course topics include plan reading, architectural drawing, sketching, drafting methods, computer aided design (CAD), and building information modeling. Conventionally, like most plan reading and entry-level CAD courses, CM4 was taught through lectures and in-classroom tutorials with less interaction and engagement. The intent of turning it into a tablet course was to bring more opportunities for class activities and group projects, which would ultimately improve active learning and communication in various forms.

CM177 is an upper level technical elective for Construction Management students. This course introduces the applied concepts of sustainability in building industry, discusses the tenets of green building and rating systems such as Leadership for Energy and Environmental Design (LEED), and demonstrates real world scenarios using case studies. In Fall 2014 CM177 was part of a pilot study on project-based learning through a joint-course project with CM132 Advanced Architectural Design. Initial assessment data were collected and analyzed. The instructors from the two courses continued to collaborate with a refined approach to tackle the challenges encountered during their first collaboration.

HRM150 is an undergraduate course designed to provide an overview of human resource management topics and issues. Human Resource Management (HRM) is concerned with employment from start to finish – job analysis, recruitment/selection, performance management, training, equal employment opportunity compliance, compensation, and labor relations. Introduction of tablets into this course was expected to facilitate in-class discussions and role-play activities with enhanced student participation.

Research Objectives and Methodology

The ultimate goal of this research was to explore effective pedagogical approaches and curriculum designs to cultivate two targeted student learning outcomes (SLOs): (1) oral/written/graphical communication, and (2) critical thinking, in a tablet-enhanced learning environment with an emphasis on active and collaborative learning. As an initial step, this paper particularly examines students' perceptions.

Project-based learning and flipped classroom pedagogies were adopted in all three courses. Project-based learning allows students to gain knowledge and skills through problems with real-world applications; whereas the flipped classroom strategically reverses activities traditionally occurring in (i.e. lectures) and outside (i.e. homework) the classroom and engages students with exercises, projects, and discussion during class time. They both are proven effective student-centered approaches promoting active learning [19][20][21][22][23][24][25].

Several sets of generic measures along with associated rubrics for the targeted SLOs were developed and tested. Table 1 below lists the direct and indirect measures used in the three courses. Comparative analysis was also conducted through a pair of surveys to inform future

Tablet PC usage and assessment efforts in both STEM and social science fields. A full discussion of all measures is beyond the scope of this paper. The results section will focus on the survey analysis only and thus provide students' perceptions.

Table 1: Direct and indirect measures to assess selected SLOs

Discipline	Course	SLOs and Associated Assessment Measures			
		Oral/Written/Graphic Communication		Critical Thinking	
		Direct Measures	Indirect Measures	Direct Measures	Indirect Measures
Construction Management	CM4 & CM177	Lab assignments, writing assignments, architectural design, Group presentations, reports	Surveys, software/app proficiency	Group project (models and reports), role play activities, class assignments	Surveys
Business Management	HRM 150	Group presentations, final paper, homework assignments, role play activities, exams with written components	Surveys	Discussions, class assignments, group research project, case analyses	Surveys

- **The Pre- and Post-Surveys**

The major indirect measure for assessment utilized in this study is a pair of surveys that investigate student perceptions towards the impacts of the tablet-enhanced learning environment on targeted SLOs in formative (mid-term) and summative (end-of-semester) terms. Relying on the rubrics generated from the VALUE project of Association of American Colleges & Universities[26], both pre- and post- surveys were designed through Qualtrics and disseminated online. The surveys consist of three major sections:

1. Demographics;
2. Knowledge and experience of tablet-enhanced learning environment; and
3. Perceptions towards impacts of tablet-enhanced learning environment on oral, written and graphical communication, and critical thinking.

Individual student learning outcomes were assessed through groups of questions as described below.

Oral Communication

Two questions were used to assess students' perceptions of gains in oral communication: 1) Do you feel that your oral communication skills benefited/improved by having access to tablets in the classroom? and 2) Which of these elements (if any) of tablet technology did you find most helpful for improvement of your oral communication? Responses for the first question simply included a yes or no option. Responses for the second question listed the following options: 1) Ability to look up unknown vocabulary quickly, 2) Ability to view examples of articulate speakers online in real-time, 3) Ability to receive instructor feedback faster, 4) Ability to record

yourself prior to presentations and identify areas for improvement in presentation skills, 5) None of these, and 6) Other.

Written Communication

Two questions were used to assess students' perceptions of gains in written communication: 1) Do you feel that your written communication skills benefited/improved by having access to tablets in the classroom? and 2) Which of these elements (if any) of tablet technology did you find most helpful for improvement of your written communication? Responses for the first question simply included a yes or no option. Responses for the second question listed the following options: 1) Ability to look up unknown vocabulary on the spot, 2) Ability to view examples of well-structured written work online quickly, 3) Ability to receive instructor feedback faster, 4) None of these, and 5) Other.

Graphic Communication

Two questions were used to assess students' perceptions of gains in graphic communication: 1) Do you feel that your graphic communication skills benefited/improved by having access to tablets in the classroom? 2) Which of these elements (if any) of tablet technology did you find most helpful for improvement of your graphic communication? Responses for the first question simply included a yes or no option. Responses for the second question listed the following options: 1) Ability to access plans and specs electronically anywhere and anytime, 2) Ability to quickly locate information, zoom in/out at a specific part of the drawing with ease, 3) Ability to reveal the inherent relationship between the graphic symbols and their real-world implications, 4) Ability to mark up plans and receive immediate feedback from the instructor, 5) Ability to share information and have real-time collaboration with classmates, 6) None of these, and 7) Other.

Critical Thinking

Assessing *Critical Thinking* in this study consisted of the use of six major metrics, i.e. *Interpretation, Analysis, Inference, Explanation, Evaluation,* and *Self-Regulation*, each of which was further represented by several sub-metrics. Students were asked to rate their engagement in these sub-metrics with a 5-point Likert scale, which in ascending order includes: 1 - *Never*, 2 - *Rarely*, 3 - *Sometimes*, 4 - *Often* and 5 - *All of the Time*. Table 2 below summarizes the metrics and sub-metrics of critical thinking. Responses to questions for each metric were averaged to create one score to represent each of the 6 dimensions of critical thinking. Same process was followed for both pre- and post-surveys.

Table 2: Metrics and sub-metrics for critical thinking assessment

Metrics	**Submetrics**
Interpretation	To what extent did you use your tablet to view graphical representations of data (e.g., blueprints, charts, graphs, tables) for research purposes?
	To what extent did having your tablet on hand allow you to look up unknown information in order to identify the main issues in articles, books, project documents and other reading materials?
Analysis	To what extent did you use your tablet to identify and research the similarities and differences between two approaches to a solution of a given problem?

Metrics	Submetrics
	To what extent did you use your tablet to examine arguments in various problems presented in class?
Inference	To what extent did you use your tablet verify claims made in your book or other reading materials?
	To what extent did you use your tablet to determine the scope of work and desired outcomes based upon the project documents provided?
Explanation	To what extent did you use your tablet to develop presentations or write papers to deliver the results of your research on various topics?
	To what extent did you use your tablet to construct a graph or chart which organizes data or your thoughts?
	To what extend did you use your tablet to specify the means and methods to meet project requirements and deliver desired outcomes?
Evaluation	To what extent did you use your tablet to verify information or examples discussed in class by the instructor or other students?
	To what extent did you use your tablet to download newspaper or journal articles to read information in order to conduct research for various assignments?
	To what extent did you use your tablet to verify credibility of media sources before including them in your oral/written assignments?
Self-regulation	To what extent did you use your tablet to take notes during lectures or on assigned readings in order to monitor how well you understood the given information?
	To what extent did you use your tablet to double check yourself by recalculating data or information before presenting in figures, tables, charts?
	To what extent did you use your tablet to conscientiously preview and review course contents, and actively participate in class activities to improve your learning outcomes?

Implementation

- **CM4**

To facilitate the transition to a tablet-enhanced learning experience, substantial course redesign was made to CM4, including the course delivery method, selection of assessment measures as well as the textbook. With a flipped classroom model, students came to class with better understanding of course contents and participation in group activities and discussions were encouraged to take advantage of the active learning affordance provided by tablets. Compared with the non-tablet version of the course, large, comprehensive assessments were converted to lighter and more focused exercises at a higher frequency. Tablets also made it possible to adopt some of the industry best practices, and develop desired skillsets that would help students gain some competitive advantage in the job market.

- **CM177**

As mentioned earlier, students from CM177 collaborated in teams with students from CM132 through a joint-course project. The two classes worked on an ongoing campus laboratory building. The goal was to develop green building strategies, create computer-aided designs, conduct performance analyses, and prepare project documentation. CM132 was not included in this study however due to the fact it was not a tablet course. It was the second time the two instructors attempted the joint-course project approach. A major adjustment made based on the feedback they received from the first experiment in Fall 2014 was that the two classes were now scheduled to take place concurrently and (even better) in adjoining classrooms. Through the window on the common wall one could see the progress in both rooms, which made it easier to have spontaneous joint-class meetings when needed and thus fostered a more collaborative learning environment. Furthermore, Google Classroom was used to manage joint-class activities for the first time.

An eText was adopted in CM177. Course contents were divided into a number of modules with each introducing a new topic. A module typically took two class periods (a week) to complete. Before the first class of each module, students were assigned online materials (e.g. videos, articles, book chapters, lecture notes, etc.) to study. An online quiz would be given through Socrative at the beginning of the first class to gauge students' level of preparation. The instructor would then give a short lecture on the new topic highlighting selected points based on the quiz results, followed by in-class exercises and discussion. In the second class of each module, a good amount of time was usually set aside for a guided joint-class meeting where students could work in teams on their project on a set of tasks closely related to the new topic introduced that week. At the end of the semester the teams were asked to create a virtual walk-through video introducing the design of the building and its green features using Autodesk screencast along with several other video editing applications.

- **HRM150**

Administration of Personnel course was conducted for 1 hour and 15 minutes twice a week. A partial flipped classroom approach was employed. Specifically, students were subjected to a traditional lecture-based pedagogy on one of the two days this course met during the week, while the second day was dedicated entirely to engaged activities, hands-on projects, and discussion. Tablets were used heavily during the second day in order to complete group assignments, collaborate, and contribute to discussion. During the first day of weekly class meetings, students were required to utilize Socrative quizzing app in order to take the weekly quiz. Finally, the culminating experience required students to research a topic and collaborate using Google Drive and Google Docs. Ultimately, groups were required to develop a multimedia presentation reporting on their research topics.

Table 3 below summarizes the list of applications along with selected functions recommended by the instructors. It also indicates frequently used applications by course. The applications are sorted into five categories based on their shared characteristics. As can be seen that the majority of them support some form of communication. It should be noted that the reason some applications were less favored could simply be the fact they were paid applications, or the university received stronger support from their competitors, or they were still fairly new in the market during the research period.

Table 3: Recommended and most frequently used applications

Category	Recommended apps	Recommended functions	Apps used most frequently		
			CM4	CM177	HRM150
Read	Adobe Reader	Reading and viewing PDF documents	X	X	X
	iAnnotate PDF	Annotating and reviewing PDF documents			
Write	Google Docs	Creating text documents and collaborating with others simultaneously	X	X	X
	Google Sheets	Creating spreadsheets and collaborating with others simultaneously	X	X	X
	Microsoft Office Mobile	Viewing and editing Microsoft Office files	X		
	Evernote	Note taking, archiving, sharing, and collaboration		X	
	Numbers	Creating and sharing spreadsheets			
Present	Google Slides	Creating and delivering presentations and collaborating with others simultaneously	X	X	X
	Keynote	Creating and delivering presentations			
	Explain Everything	Interactive whiteboard presentation and screencasting			
	Nearpod	Creating and delivering interactive presentations			
	Flipboard	Presenting, sharing and curating relevant study materials			X
	TouchCast	Creating and editing videos		X	
Manage	Blackboard	Course management	X	X	X
	Google Classroom	Course management		X	
	Socrative	Giving quizzes/quick questions and receiving instant feedback	X	X	X
	Google Drive	File storage, sharing, and collaboration	X	X	X
	Box	File storage, sharing, and collaboration			
Manage (Discipline Specific)	Autodesk A360	Model management and sharing	X	X	
	PlanGrid	Reading, viewing, and sharing architectural plans	X	X	

Survey Results and Discussion

Student participation in the two surveys was completely voluntary. Nevertheless, investigators did provide incentives (i.e. extra credit) to encourage responses. A total of 103 students (27 combined in courses CM4 & CM177 due to small class sizes and 76 in course HRM150) were reached with 86 and 92 completed responses from the pre-survey (response rate = 83.5%) and the post-survey (response rate = 89.3%), respectively. However, after responses from pre- and post-surveys were linked, only 17 usable data points were recovered from the CM4 & CM177 sample and 56 from the HRM150 sample. The rest of the respondents either completed only the pre-survey or the post-survey, rendering it unusable for comparison purposes. These were ultimately eliminated from the final dataset.

- ***Demographics***

Construction Management Sample
Seventeen undergraduate Construction Management students completed both pre- and post-surveys. Of these participants, 15 were male and 2 were female. On average, participants were 23.35 years old (*SD* = 2.29; range = 19-26 years), and held sophomore (35%) and junior (47%) class standing. English was first language for a little over half (53%) of the class. Latino or Hispanic was the major ethnic group (59%), others include Caucasian (18%), Asian/Pacific Islanders (6%), and undeclared (18%). None of the participants reported to have taken courses that required regular tablet usages, despite substantial skills with tablets reported by students (over 53% claimed to be advanced or expert users). Participants also indicated frequent usage of other technology including desktop and laptop computers as well as smartphones, and expressed little concern over the integration of tablets into the classes they enrolled in.

Business Management Sample
Fifty-six undergraduate students from Human Resources Management- Administration of Personnel course completed both the mid-semester and end-of-semester surveys. Of these participants, 28 were female and 28 were male. On average, participants were 24.32 years old (*SD* = 4.80; range = 21–45 years), majority of whom held senior class standing (75%), with a little over half of the population (31 persons or 55.4%) claiming that English was their first language. When asked which racial or ethnic groups they most identified with, majority were either Hispanic (32.1%) or Caucasian (32.1%). In addition, most of responders (87.5%) claimed to have never had courses that required usage of tablets on a regular basis. However, all participants reported using some form of technology (e.g. desktop computers, laptops, mobile phones) during the previous school year, indicating at least basic comfort with the use of technology in everyday life.

- ***Oral Communication***

Construction Management Sample
Among the Construction Management respondents, the majority (71%) of them in the pre-survey (mid-term) acknowledged improvements and benefits to oral communication by having access to tablets. A lower percentage (59%) confirmed such improvements and benefits in the post-survey (end-of-semester). This could be partly due to the fact that students were asked to produce video presentations using certain applications whose functions were limited on tablets.

According to Figure 1, students indicated the *ability to look up unknown vocabulary quickly* and the *ability to receive instructor feedback faster* as top enablers of the tablet technology.

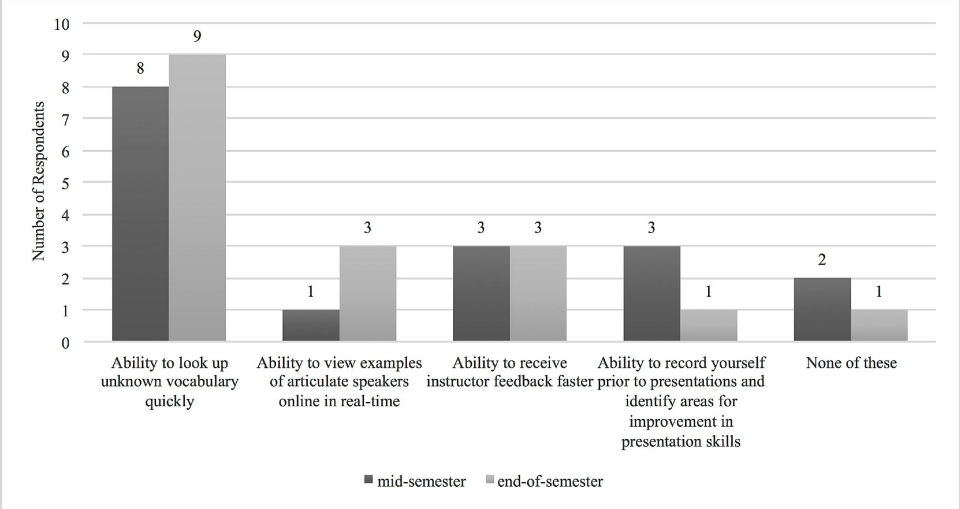

Figure 1. Survey results from Construction Management students on Oral Communication

Business Management Sample

The mid-semester survey asked students whether they felt that their oral communication skills improved by having access to tablets in the classroom. Thirty one students (55.4%) claimed that their oral communication skills benefited from having access to tablet technology in the classroom, while the remaining 25 students (44.6%) did not. The post-survey indicated that 75.6% of students considered tablets useful for improvement of oral communication from some to very great extent. Figure 2 illustrates student responses on the initial and end-of-the-semester surveys regarding most useful aspects of tablet technology for oral communication purposes. As can be seen from the graph, students found the ability to look up unknown vocabulary to be the most useful aspect of tablet technology for improvement of oral communication skills.

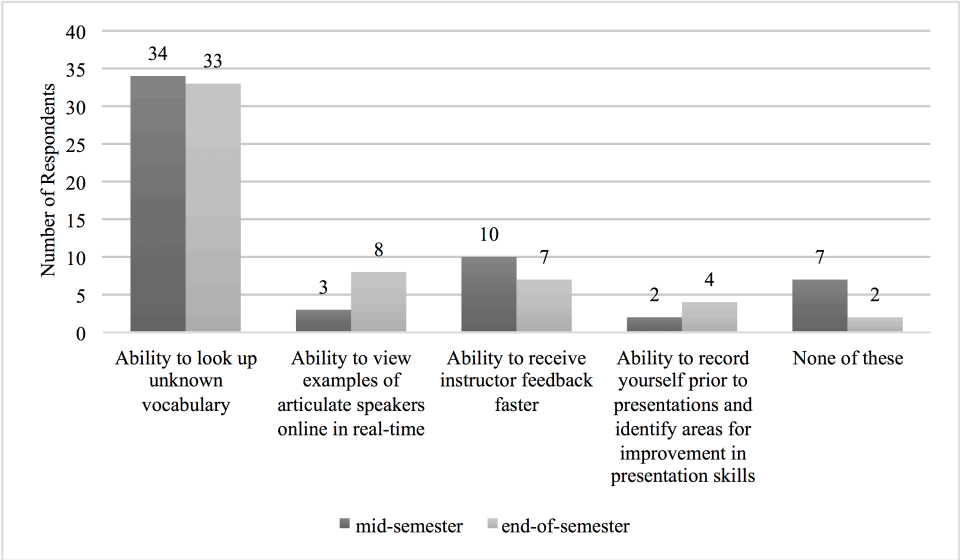

Figure 2. Survey results from Business Management students on Oral Communication

- ***Written Communication***

Construction Management Sample

In the pre-survey, 76% of CM respondents acknowledged improvements and benefits to written communication by having access to tablets. The post-survey confirmed with 82% respondents indicating some extent of improvement and nearly half (47%) indicated great extent or very great extent of improvement. The top contributing factors of tablet technology, as shown in Figure 3, including *ability to look up unknown vocabulary on the spot* and *ability to view examples of well-structured written work online quickly*.

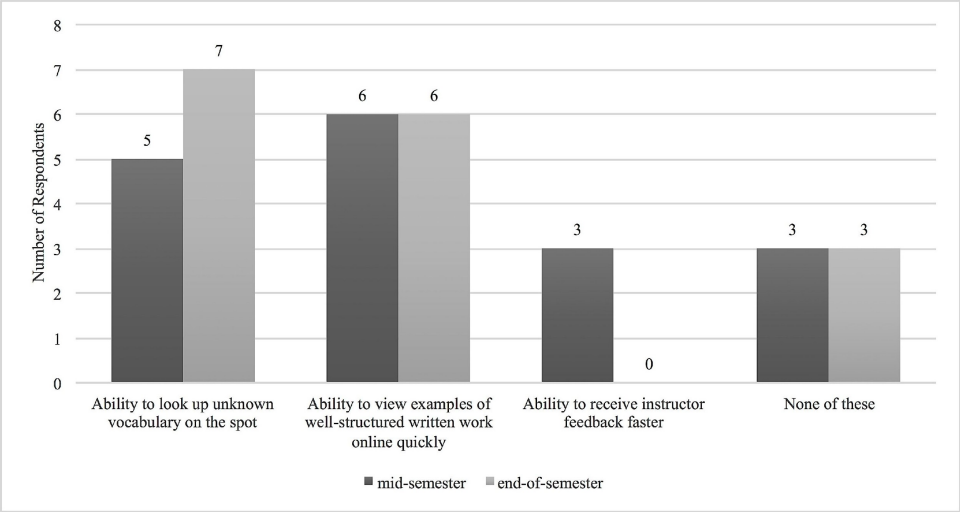

Figure 3. Survey results from Construction Management students on Written Communication

Business Management Sample

The mid-semester survey asked students whether they felt that their written communication skills improved by having access to tablets in the classroom. Unlike oral communication, students saw more benefit of tablet technology for their written communication skills with forty-one students (73.2%) finding tablets useful for honing their written skills. The post-survey also indicated that the majority of students found tablets to be useful for development of written communication skills (89.1% reported tablets to be useful from some to very great extent). Figure 4 illustrates student responses on the initial and end-of-the-semester surveys regarding most useful aspects of tablet technology for written communication purposes. Written communication skills appeared to have benefited mostly from the ability to look up unknown vocabulary on the spot and viewing examples of well-written work online for inspiration. Interestingly, we saw an increase in students seeing the usefulness of viewing examples of well-written work online via tablets on the end-of-semester survey, suggesting that students discovered the usefulness of tablets for this endeavor over the course of the semester.

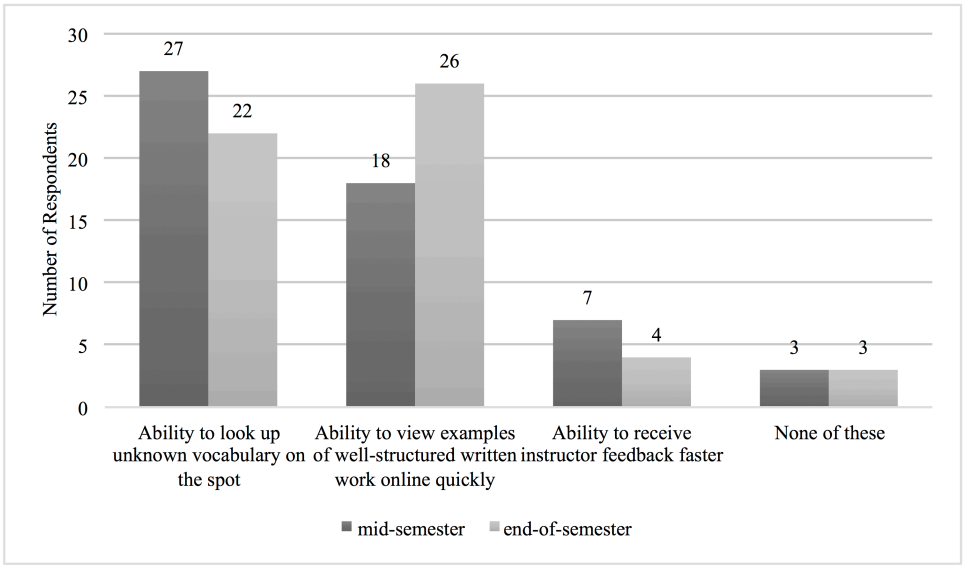

Figure 4. Survey results from Business Management students on Written Communication

- ***Graphic Communication***

Construction Management Sample

Given that graphic communication was not a relevant learning outcome for the selected Business Management course this part of the results was only analyzed for CM students. In the pre-survey, 76% of the respondents acknowledged improvement in graphic communication by having access to tablets, and 83% in the post-survey confirmed such improvement to be at great or very great extent. Specifically, according to Figure 5, *ability to access plans and specifications electronically anywhere & anytime* stood out as the top enabler by the tablet technology. It is also interesting to notice that through experiential course projects, more respondents recognized the *ability to reveal the inherent relationship between the graphic symbols and their real-world implications*.

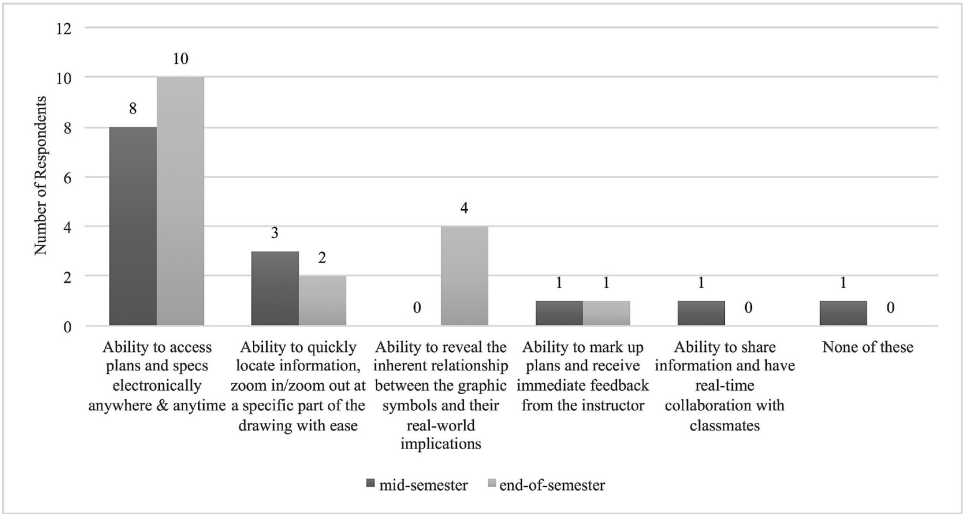

Figure 5. Survey results from Construction Management students on Graphic Communication

- ***Critical Thinking***

Construction Management Sample

Figure 6 illustrated the mean Likert ratings of responses by each metrics. Given the small sample size (17), no inferential statistics would be feasible at this point. Nevertheless, it is possible to observe a general trend that over the course of the semester there were positive outcomes of having access to tablets on five out of the six sub-dimensions of critical thinking, with the only exception of *Inference*.

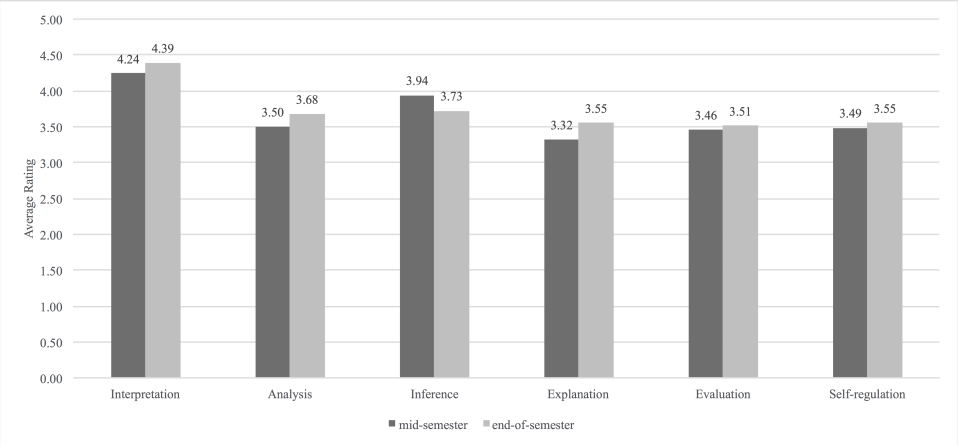

Figure 6. Survey results from Construction Management students on Critical Thinking

Business Management Sample

As can be seen from Figure 7, students perceived an increase in the various critical thinking dimensions from mid-semester to the end-of-the-semester. For the most part, students transitioned to a more frequent usage of tablets for the improvement of the various critical thinking skills with time.

Six paired-samples t-tests were performed to assess whether there was a significant difference between mid-semester and end-of-semester ratings on each of the sub-dimensions of critical thinking. Of the six sub-dimensions, two (Analysis and Explanation) revealed a significant difference between the two administrations of the survey. Specifically, there were significant differences in the perception ratings for Analysis between the mid-semester and end-of-semester survey, $t(50) = 2.63$, $p < .05$, $d = .36$. Similarly, Explanation was another dimension that indicated a significant increase in perceptions of improvement between mid-semester and end-of-semester survey, $t(50) = 2.59$, $p < .05$, $d = .32$. Cohen's d effect sizes were .36 and .32, indicating a close to medium effects for those two sub-dimensions of critical thinking. Given these findings, we saw a positive effect on all six sub-dimensions of critical thinking, with two revealing a significant difference between pre and post surveys.

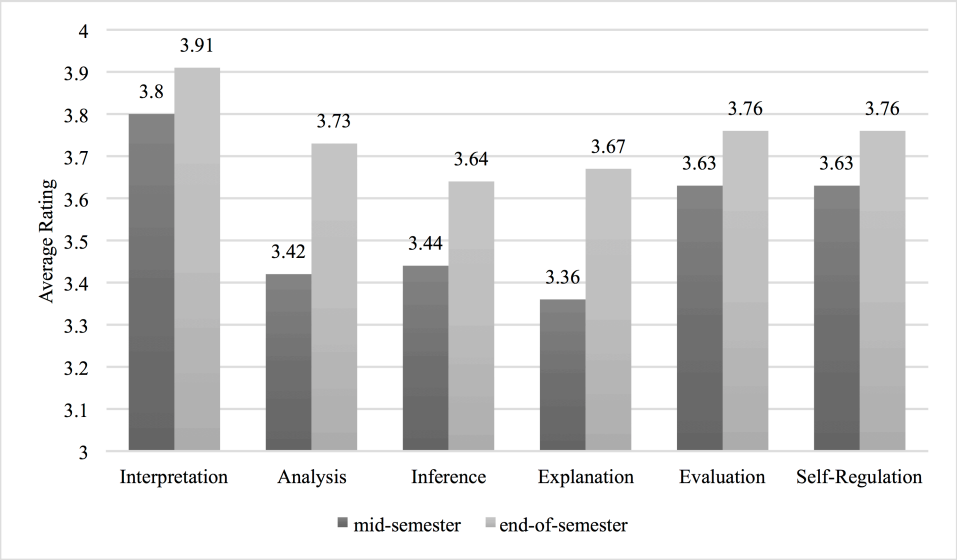

Figure 7. Survey results from Business Management students on Critical Thinking

Concluding Remarks and Future Work

In this study, through a pair of mid-semester and end-of-semester surveys administered in three tablet courses, the researchers closely examined Construction Management and Business Management students' perceptions regarding the impact of a tablet-enhanced collaborative learning environment on the development of their communication and critical thinking skills. Analysis of the results suggests a number of implications to educators in STEM and social science fields.

- The majority of the young generation have had some exposure to computing technology and are comfortable in a tablet course even if they have never taken one before.
- A tablet-enhanced collaborative learning environment provides opportunities to practice and hone communication and critical thinking skills in new formats.
- Students from both disciplines acknowledged the ability to look up unknown vocabulary quickly and receive instructor feedback faster as the two most useful aspects of tablet technology for improvement of oral communication skills.
- Compared to oral communication, students from both disciplines saw more benefits of tablet technology for improvement of written communication skills and acknowledged the ability to look up unknown vocabulary on the spot and to view examples of well-structured written work online quickly as the two most helpful aspects of tablet technology.
- Construction Management students appreciated the great convenience brought by tablet technology and believed it helped them improve their graphic communication skills by allowing them to access plans and specifications electronically anywhere and anytime, and the ability to reveal the inherent relationship between the graphic symbols and their real-world implications. Students from other engineering fields should also be able to take advantage of these features.
- Despite the small sample size of Construction Management students, researchers in both disciplines observed a general trend of positive impact from tablet usage on the sub-

dimensions of critical thinking, with Analysis and Explanation showing a significant difference between pre and post surveys among Business Management students.

The findings of this study provide valuable insights on students' acceptance and preferences regarding various aspects of tablet technology. They can serve as an initial guide to help identify and develop effective teaching strategies cultivating communication and critical thinking skills in a tablet-enhanced collaborative learning environment. A follow-up study with results from direct measures would complement the analysis presented here and provide useful information for future implementation.

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