Computers & Education 107 (2017) 91–99

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Impact of mobile technology on student attitudes, engagement, and learning

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ARTICLE INFO

Article history:
Received 17 October 2016
Received in revised form 6 January 2017
Accepted 7 January 2017
Available online 9 January 2017

Keywords:
Collaborative learning
Mobile technology
Media in education
Student engagement
Pedagogy

ABSTRACT

Mobile devices and collaborative learning environments are common tools in education but not all collaborative learning is structured the same. This study evaluated student learning in three different collaborative learning environments, both with and without mobile technology, to assess students' engagement, critical thinking, and attitudes toward collaborative learning. The results indicate that mobile technology is associated with positive student perceptions of collaborative learning but with increased disengagement by students during class. In addition, the level of students' critical thinking was more closely associated with the tools used to construct written responses than with the collaborative learning environment style. Students constructing paragraph responses on a mobile device demonstrated significantly less critical thinking than those who used a computer keyboard or wrote responses by hand.

1. Introduction

1.1. Mobile devices

As the use of mobile devices has proliferated, so has the concept that such devices may be useful in the process of teaching and learning (Khaddage, Muller, & Flintoff, 2016; Eppard, Nasser, & Reddy, 2016). The use of mobile technology in education provides educators with the opportunity to reimagine teaching and learning. This creates a more flexible learning model that gives both faculty members and students access to multiple information sources and a shift from an authority based learning structure to a structure based upon the concept of a community of learners (Hamm, Saltsman, Jones, Baldridge, & Perkins, 2013; Peters, 2007). As educators consider the best ways to use mobility to promote learning, it is important to examine strategies of both mobile learning and collaborative learning, and the best ways to blend the two to create effective learning experiences for students.

1.2. Mobile learning and collaboration

With the onset of ubiquitous handheld technology, teachers are also exploring opportunities to combine mobile devices with collaborative learning environments in order to enhance learning. The challenge is that some educational uses of mobile devices result in negative experiences for students who have difficulty with the tools being used (Ting, 2012). Students may

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http://dx.doi.org/10.1016/j.compedu.2017.01.006

also be distracted by multitasking on devices and distract fellow students by their technology use (Bellur, Nowak, & Hull, 2015; Dietz & Henrich, 2014; Junco, 2012; Ravizza, Hambrick, & Fenn, 2014; Sana, Weston, & Cepeda, 2013). Conversely, others report mobile technology improves students' perceptions of collaborative learning (Lai & Wu, 2006). In whatever ways they are employed, mobile devices and educational applications should not "complicate the learning process, but facilitate mobile learners' learning" (Jeng, Wu, Huang, Tan, & Yang, 2010). To this end, teachers are using mobile applications and classroom response systems that permit student replies to instructor questions based on course content. This has been shown to improve student perceptions of learning, engagement, and actual assessment scores (Denker, 2013; Jones, Crandall, Vogler, & Robinson, 2013). The use of these applications provides teachers with the opportunity to use mobile technology to promote significant learning. Although many teachers are using technology in their classes, a 2013 review of research on computer-supported collaborative learning revealed a dearth of sufficient studies on current mobile technology and small groups (Hsu & Ching, 2013). A 2016 meta-analysis of 110 experimental and quasi-experimental studies published between 1993 and 2013 that investigated the effects of integrating mobile devices on student learning indicated that the overall effect of using mobile devices appears to be better for learning than the use of desktop computers or not using devices at all (Sung, Change, & Liu, 2016). These authors suggest that the use of mobile devices and educational software in general is most effective when teachers are able to design the learning experience to match the device, program, and/or software with the learning outcome goals of the educational experience.

1.3. Model of mobile learning

Park (2011) adapted Gay, Rieger, and Bennington's (2002) model to develop a framework for understanding different types of mobile learning. This framework includes a mobility hierarchy, ranging from 1 to 4. Level 1 is content intensive and focuses on production. This level includes asynchronous applications such as calendars and grading. Level 2 focuses on flexible physical access and includes local databases and interactive prompting. Level 3 uses mobility applications that capture and integrate data. These include network databases, data collection, and mobile libraries. Level 4 mobile learning applications allow for communication and collaboration. These applications include real time chat, email, group use applications, and social media. Level 4 applications of mobile learning allow for intense communication and synchronous group work.

1.4. Model for creating significant learning

This model of mobile learning provides a structure to choose the best types of mobile applications for different types of learning activities. It integrates well with Dee Fink's (2003) taxonomy for creating significant learning. Fink's model goes beyond the cognitive taxonomy of learning provided by Bloom (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) and considers aspects of learning such as helping students learn how to learn and develop life skills that impact communication, interpersonal relationships, and the ability to adapt to change (Fink, 2003). Fink's taxonomy of significant learning includes six kinds of learning. The first type of learning is foundational knowledge, which includes understanding and remembering information and ideas. Application is the second type of learning, and involves developing particular skill sets, critical, creative, and practical thinking, and managing projects. The third type of learning is integration, which encompasses connecting people, ideas, and realms of life. As students learn about themselves and others, they are engaged in the fourth type of learning, the human dimension. Developing new feelings, interests, and values is a part of caring, which is the fifth type of learning. Finally, the sixth type of learning involves learning how to learn as one becomes a better student, inquires about a subject, and becomes more self-directed.

In order to fully realize the impact of mobile learning, activities must be carefully developed to use the strengths of mobility to promote significant learning. As teachers develop learning experiences that encourage students to communicate and collaborate, understanding these two models allows them to choose mobile applications that promote their chosen learning objectives. Students who engage in activities that allow them to collaborate with one another in the process of learning instead of being isolated in interacting with content are more likely to experience significant learning.

1.5. Student engagement, collaboration, and mobile learning

Student engagement can be understood using Cole & Chan, 1994 definition (p. 259) as "the extent of students' involvement and active participation in learning activities." Student engagement through active classroom participation is an important ingredient for learning that has many educational benefits for students (Berman, 2014; Kuh, 2009; Lippmann, 2013; Rocca, 2010). Collaborative learning environments, or small groups, are recognized by faculty and students as one effective strategy for promoting student engagement and learning (Lumpkin, Achen, & Dodd, 2015). In one study, students' overall satisfaction with small groups was greater than their satisfaction with full-class or online discussions (Hamann, Pollock, & Wilson, 2012). These students reported that small groups were more likely to "stimulate interest" and help them engage the material (p.72). While there are many strategies teachers can employ in pursuit of student engagement, highly structured small groups "with accountability measures built in" have a good chance of engaging more students than large group discussion (O'Connor, 2013). Some of these accountability measures include assigning roles to each student and requiring a written response from small groups based on their discussion so that students are actively engaged during the collaborative learning time (AlKandari, 2012).

The literature has also shown mobile learning to be beneficial in increasing student independence, engagement, and communication (Dunn, Richardson, Oprescu, & McDonald, 2013; Hamm et al., 2013; Junco, Heiberger, & Loken, 2011). Researchers have posited that the use of mobile devices in learning enhance engagement through providing immediate access to information as well as providing enhanced hands-on learning (Cheng, Yang, Chang, & Kuo, 2016), but warn that mobile devices are most conducive to learning when instruction has been carefully designed to make optimal use of the technology.

1.6. Purposes of this study

The purpose of the current study was to evaluate the efficacy of mobile technology used in collaborative learning environments in relation to student's attitudes, engagement and critical thinking. Specifically, three research questions guided the research: a) How does the use of mobile technology impact student perceptions of collaborative learning groups? b) How does mobile technology facilitate student engagement during collaborative learning? c) How does mobile technology affect the demonstration of critical thinking in writing products created during collaborative learning?

2. Method

A quasi-experimental research design was used to investigate the effectiveness of mobile technology used within a collaborative learning experience to facilitate student engagement and critical thinking. Using a multimethod model of analyzing effectiveness based on Lai and Wu, 2006 study, various data sources were used. These included student questionnaires, classroom behavioral observation, and a completed written product.

Participants in the study were six intact classes of first year students in a four year comprehensive university program. Over the span of three months, 159 students in two first-year general education college courses were invited to participate in this randomized controlled trial. There were a total of 102 females and 57 males who participated in the study. Each section of students was randomly assigned to one of three types of collaborative learning environments: common practice, intentional practice, and HeadsUp (Table 1). HeadsUp is a mobile application to facilitate small group interactions by allowing instructors to distribute discussion prompts that are sent to students' mobile devices. The information students receive on their devices within the HeadsUp application directs them to a randomly selected group of students and assigns each student a role for a group conversation. The roles assigned were leader, author/reporter, time-keeper, and referee. The specific responsibilities of each role were outlined for students within the application.

Students in each intact class were divided into small groups of three to five students. They were then divided into three types of groups using Brame and Biel, 2015 model of types of cooperative learning groups, both formal and informal. The groups moved from least formal to most formal, with each type of group becoming progressively more controlled by the choices of the instructor. For all groups, the instructor defined the learning objectives of the cooperative learning activity. These three groups were identified as “common practice,” “intentional practice,” and “HeadsUp.”

The common practice groups were what Brame and Biel term “ad hoc informal groups,” formed by near neighbors within the classroom (2015). In the common practice groups the instructor read the prompt aloud but did not assign students to groups or assign roles within groups.

The intentional practice groups were based on Brame and Biel's “formal cooperative learning groups” in which students are intentionally given specific roles to play within the group. In the intentional practice groups the instructor read the prompt, distributed this prompt on paper to students, randomly assigned roles to group members, but allowed students to self-select into groups.

Finally, the HeadsUp group was the most formally organized. In this type of group the instructor read the prompt aloud, the prompt was distributed to students on their mobile devices, the students were randomly assigned group roles during the discussion via mobile devices, and they were randomly assigned to discussion groups through the HeadsUp application without consideration of gender or ability level. Students who participated in the study used their personal iPhones or iPads for the HeadsUp portion of the study as all first-year students were required to own one of these two devices. There were 52 students in 13 “common practice” groups. There were 55 students in 13 “intentional practice” groups, and there were 52 students in 13 “HeadsUp” groups.

Each section of students met in the Learning Research Lab of the Adams Center for Teaching & Learning at our university for one hour to participate in the study. This is a room specifically designed to conduct video research. There are five tables in

Table 1
Collaborative learning types.

	Common Practice	Intentional Practice	HeadsUp
Prompt	Instructor read discussion prompt; no written prompt given	Instructor read discussion prompt; written prompt given as handout	Instructor read discussion prompt; written prompt given via HeadsUp app
Roles	No group roles assigned	Randomly assigned group roles via paper: Leader, Author/Reporter, Time-Keeper, Referee	Randomly assigned roles via HeadsUp app: Leader, Author/Reporter, Time-Keeper, Referee
Groups	Student groups created by self-selection	Student groups created by self-selection	Student groups assigned randomly via HeadsUp

the room with chairs at each table. Five cameras are mounted on the walls seven feet off the ground to provide a clear video recording of what occurs at each table. Due to the limited seating in the Learning Research Lab, a total of 11 classroom sessions were required in order to accommodate all of the students and complete the research study.

At the beginning of each session students signed participation forms consenting to being video recorded during the study. Video recording was used to observe student activity during small group conversations so that their behaviors could be coded by the researchers following the classroom session to determine their engagement and disengagement during the session. Research has shown that student behavioral engagement has been operationalized in many ways, including tracking of gaze, eye contact, on-task behavior, active participation, and off-task behavior (Henrie, Halverson, & Graham, 2015). According to Henrie et al. (2015), only 39.8% of studies measuring student engagement include an observational component in measurement of engagement, and these researchers note that there is not current agreement on a particular protocol for measuring behavioral engagement. In the current study, the researchers used Lane and Harris (2015) Behavioral Engagement Related to Instruction (BERI) categories as a model for developing the coding for engaged and disengaged behaviors in the video recordings analyzed. The BERI model is especially relevant to this study because it was developed for the context of higher education and use within larger classes. We adapted the BERI categories due to our use of a small group collaborative activity rather than a typical university lecture or large group setting. The specific categories adapted from the BERI for engaged behavior were listening, which in our study focused on eye contact, gestures, posture shifts, and emotional response, engaged computer use, and engaged student interaction. The behaviors categories adapted from the BERI for disengaged behavior were unresponsive, which included lack of eye contact, sleeping, posture, and facial expressions, off-task, disengaged computer use, and disengaged student interaction.

Prior to the first session the group types for each session were chosen by random selection so that each one-hour class was established as a common practice, intentional practice, or HeadsUp collaborative learning environment. In the sessions designated as HeadsUp the first few minutes of class were used to help students access the HeadsUp web page on their mobile devices and join the session with a code.

Prior to the study the researchers created a small group discussion prompt that required critical thinking and analysis in order to reach a conclusion. Five faculty members not involved in the study evaluated this discussion prompt to assess its validity. The prompt instructed students to consider adolescent deaths by motor vehicle accidents, the higher insurance rates for younger drivers, and the current laws regarding the age of receiving a driver's license, and then to present an argument that either supports the current minimum driving age at 16 or to present an argument that supports moving the minimum age to 18 years old. Once the prompt was read the students were given 15 min to discuss the prompt in their small groups and to create a written paragraph response that communicated their group's decision. The students were invited to submit these written responses on paper or through email to the researchers at the conclusion of each session.

At the conclusion of the collaborative learning time students were also given an electronic survey that inquired about their affinity for small groups, their interactions with the instructor and their interactions with their peers. For the groups using HeadsUp there were questions regarding their experience with the technology.

3. Results

This study relied on three forms of data for analysis: video footage of each student small-group interaction, a written or typed response from each group outlining the rationale for their decision, and an end-of-class questionnaire about students' perceptions and experiences.

3.1. Video

After the in-class sessions with students the video for each session was reviewed and analyzed for evidence of student engagement in cooperative learning environments with the assistance of the OvoLogger video capture program. This research software was used to tag student behaviors and code them as engaged or disengaged. Using Cole and Chan, 1994 definition and behaviors suggested by the BERI, we defined engaged students as those active in the learning process. Engaged students are devoting attention to both the other small group members and to the assignment task through observable behaviors of engagement. Conversely, when students are not engaged there are specific observable behaviors that signal disengagement (Table 2).

Table 2
Criteria for coding student engagement.

	Engaged	Disengaged
Emotional Response	Smiling, laughing, anger, or showing emotional investment	Disengaged emotionally
Eye Contact	Looking at the person talking; appears to be listening	Looking away from the person talking; appears not to be listening
Gesturing	Moving hands to communicate	Hands are not used to communicate
Posture	Leaning forward; facing toward group; awake	Leaning back; facing away from group; asleep
Speech	Contributing verbally to the conversation	Remaining silent
Technology Use	Using technology for the purpose of the group: note-taking	Texting, surfing the web, or using technology unrelated to group work

Three reviewers independently observed and coded the first small group using the Criteria for Coding Student Engagement and then met to discuss their results in order to improve inter-rater reliability. The reviewers then proceeded to observe the first seven minutes of each of the 39 small groups as a unit of analysis and coded each student's behavior throughout that time as students demonstrated either engaged or disengaged actions. Each occurrence of the indicated engaged or disengaged behaviours were recorded by tagging the appropriate boxes on the OvoLogger software.

By adding up the frequency counts of each behavior across all teams within each type of learning group we obtained the data presented in Table 3. The total number of all engaged behaviors evident in common practice collaborative learning groups (1451) and the intentional practice collaborative groups (1479) were very similar, but each of these had more than in the HeadsUp groups (1175). Similarly, the HeadsUp groups demonstrated more signs of disengagement than the other two group types (Table 3). A Chi-square test was performed to compare frequency of engaged and disengaged behaviors across groups $X2(2, n = 2819) = 662.67$, $p = 0.000$. A significant difference was found across all group behavior totals.

When students were engaged in the group process they were most likely to be engaged through speech (1576), making eye contact (943), gesturing (709), or through their posture (534). Conversely, when students were disengaged, they were most frequently disengaged with technology (245), eye contact (210), and posture (130). A Chi-square analysis was done to compare group frequencies by specific behavior type for both engaged and disengaged behavior types $X2(5, n = 4105) = 2071.96$, $p = 0.000$. A significant difference was found between engaged and disengaged behavior totals across all 6 observed behavior types. (see Fig. 1)

3.2. Paragraph responses

In addition to student engagement, each small group's written response to the discussion prompt was evaluated for evidence of critical thinking (specifically, analysis and evaluation). After a graduate assistant compiled all responses into a typed, shared document, the researchers blind evaluated three of the paragraphs to establish inter-rater reliability. Then, the researchers blind evaluated the remaining paragraphs and assigned a numerical score to each paragraph response. The tool used during this assessment was a Likert-type ranking between poor (1) and excellent (5) on nine different measures of critical thinking. These nine measures were assessing adequacy of the argument, pertinence to the issue, objectivity, reasoning, focus, information used, tools used, a clear decision reached, and logic used in the process. The highest possible score was 45 points. The mean written paragraph score of the groups were as follows: common practice groups ($m = 29.2$, $\sigma = 5.4$), intentional practice groups ($m = 27.8$, $\sigma = 6.9$) and HeadsUp groups ($m = 26.3$, $\sigma = 5.3$). A One-way ANOVA was done to compare means across group type. No significant differences were found.

3.3. Questionnaire

At the conclusion of each session students were also invited to respond to a brief electronic survey about their experience. This was a 4-item self-evaluation form for the common practice and intentional practice groups and a 10-item self-evaluation form when HeadsUp was employed in the session. Students responded using 5-point Likert-type scale ranging from strongly disagree (1) to strongly agree (5). The survey included items that assessed for positive group interactions, prior use of the HeadsUp application, and enjoyment of collaborative learning activities, in addition to questions specific to HeadsUp. There was general affinity for collaborative learning in all groups: common practice ($m = 4.26$, $SD = 0.83$), best practice ($m = 4.13$, $SD = 0.76$) and HeadsUp ($m = 4.11$, $SD = 0.80$). A factorial ANOVA was run across response means but no significant differences were found.

3.4. Response type

After reviewing the data, a variable related to the third research question, considering how mobile technology affects the demonstration of critical thinking in written products, stood out within our data set. Video and student responses were reviewed and coded in one of three ways; written with pen and paper, typed on a computer with a traditional QWERTY keyboard, or typed on a mobile device. A one-way ANOVA was run comparing response type (written, computer, mobile device) and mean group paragraph response rubric scores. Significant change ($p < 0.008$) was found between groups, with post-hoc analysis revealing that significance lies primarily between the mobile device response group and the computer response group ($p < 0.006$). (see Table 4)

Table 3
Total observed behaviors by collaborative learning group type.

	Common Practice	Intentional Practice	HeadsUp
Engaged Behaviors	1451	1479	1175
Disengaged Behaviors	139	144	324

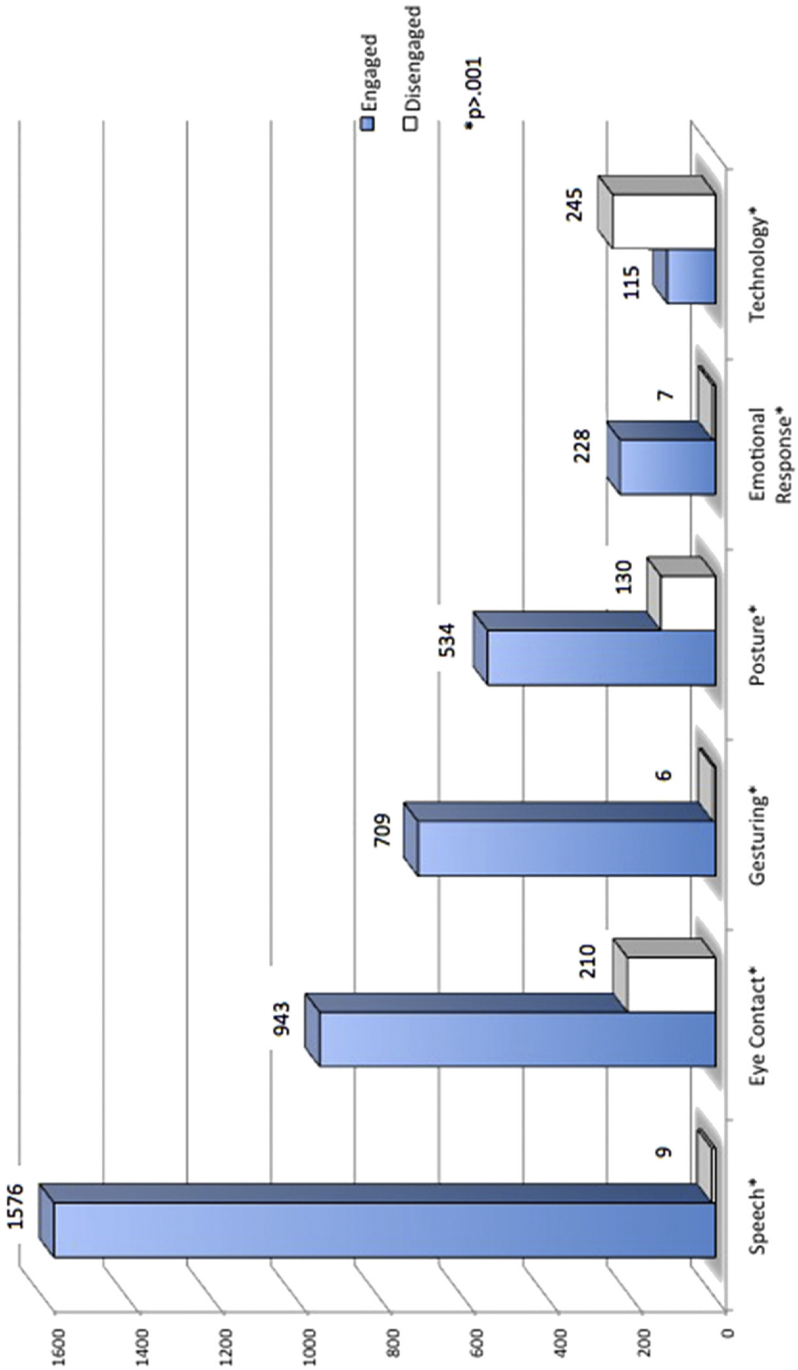

Fig. 1. Total observed behaviors of all groups.

Table 4
Critical thinking paragraph response score by response type.

Tool used to create paragraph:	Mobile Device	Written	Computer
Mean paragraph response score:	22.9	27.7	31.5

4. Discussion

The results of this study raise concerns about the use of mobile devices in the classroom, particularly in creating academic artifacts designed to demonstrate critical thinking. Student work products produced on mobile devices were rated significantly lower on evidence of critical thinking demonstrated by analysis and evaluation than those produced on laptop computers or paper and pen. In addition, the pattern of the chi-square analysis indicate that there was a significant difference in engagement and disengagement between the HeadsUp group and the other two, with the HeadsUp group having significantly fewer engaged behaviors and more disengaged behaviors. As noted by previous researchers, it is key when developing instructional programming to consider the design carefully in order to assure that the mobile device and educational application creates opportunities to enhance student learning rather than complicating or distracting from learning (Cheng et al., 2016; Hsu & Ching, 2013; Jeng et al., 2010; Sung et al., 2016).

The collaborative learning environments in this study were a “low transactional distance and socialized mobile learning activity” defined by minimal instructor lecture, group discussion focused on a problem to solve, and natural social interaction among students (Park, 2011). These groups built on the concept of a community of learners (Hamm et al., 2013; Peters, 2007), and gave students the opportunity to demonstrate initiative for their own group process as they were responsible for discussion and the creation of the final product: the written response articulating their position in response to the prompt.

Interestingly, as the small groups were assessed, technology was the variable most associated with disengagement, followed by eye contact and posture. These patterns may confirm many teachers' existing beliefs about effective small groups and human communication: when students are engaged they are speaking and looking at each other while refraining from looking at technology. When students in this study were disengaged they were most often seen looking at technology or looking away from the speaker at something else. Of related importance is the issue of posture. It is difficult to say if disengagement is displayed in posture or if poor posture contributes to disengagement. Therefore, it is recommended that teachers educate students on the responsibility of small group members to communicate engagement through good posture rather than slouching, facing away from the group, or unnecessarily distancing themselves from others. Interestingly, based on observed behavior, technology was the only variable whose presence in collaborative learning environments was more likely to signal disengagement than engagement in group participants.

The paragraph responses composed by each group were useful to assess critical thinking about the issue the students were given to discuss. The researchers wanted to discern whether the small group type impacted critical thinking. It was not predicted that the common practice groups would outperform the other two groups on measures of critical thinking. This prompted the researchers to question if there might be another variable at work that influenced the scores. Additional analysis of the data revealed the presence of a confounding variable: the tools used to construct paragraph responses. Instead of the collaborative learning environment format, it was the method of communicating that was most associated with students' use of critical thinking. In light of this, we recommend that students generate paragraph responses with computers or on paper rather than with a mobile device. When students use mobile devices to generate academic writing, it is possible they slip into a genre of abbreviated communicating common to social media that is less formal and less reflective.

The questionnaire provided to all students at the end of each class session allowed students to communicate their affinity for collaborative learning and for the HeadsUp mobile technology. Because students participating in the study came from various classes across campus, some of the students had been exposed to the HeadsUp application by their instructors prior to the study. The researchers noted that those who had used the HeadsUp application prior to the study had more positive perceptions of collaborative learning environments as well as the technology tool itself. This coincides with Ting’s (2012) beliefs that positive student experiences with mobile devices improve student attitudes towards technology. It is possible that those students who were familiar with the tool focused more on the task at hand rather than dwelling on the use of the technology, allowing them to offer attention to their peers.

While most research studies dealing with mobile technology employ surveys and experimental methods, a minority include observation (Wu et al., 2012), possibly due in part to the large time commitment involved in coding behaviors on video. The time commitment is only one of several challenges of video observations. Another limitation is that the video does not always contain audio. This was a limitation of the study that may have impacted the interpretation of certain behaviors. Finally, by nature of the observation task, it was easier to discern student engagement through speech, eye contact, gestures, and posture than it was to discern engagement through the use of technology.

In addition, it is our recommendation that this study be replicated while controlling for response type, specifically insisting that all students type responses on a computer in order to standardize response format. Future studies could further investigate the connections between critical thinking and the forms of written responses from students.

5. Conclusions

When students are engaged in collaborative learning environments they are most frequently demonstrating that engagement through speech, eye contact, gesturing, and posture. Those who are disengaged most often are found looking at technology, not making eye contact, and posturing themselves in ways that are not participatory. HeadsUp and other mobile applications are useful teaching tools that can be selectively used to facilitate collaborative learning environments. It should be noted that any use of technology for learning also presents the opportunity for student distraction, and therefore, disengagement. HeadsUp is effective in placing students in small groups, assigning roles, and distributing prompts, but it is limited in its usefulness as a tool to inspire attentiveness to others, or to produce written responses. Finally, students who compose written work through short-hand typing on a mobile device appear less likely to demonstrate deep critical thinking than students who compose their written responses on a computer or on paper. Together, these results suggest that educators can employ many different tools to create engaged learning environments but each tool has both primary functions and limitations.

Acknowledgment

This research was supported in part by a grant from the Adams Center for Teaching and Learning at Abilene Christian University, Abilene, Texas.

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