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MOBILE LEARNING IN AN ONLINE SCIENCE METHODS COURSE

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ABSTRACT

The purpose of this research is to investigate how mobile learning activities facilitate a scientific investigation in an online science methods course. During a four week investigation, students collected data about the decomposition of household items within a constructed column and then reported on changes seen during the decomposition process. Analysis of data from this research indicates the presence of both planned and unplanned mobile learning activities facilitating the student investigation. The planned mobile learning activities include column construction, photography, journaling, and online discussions. The identified unplanned mobile learning activities include accessing external resources for content support, incorporating the participation of other individuals, replication of the investigation, as well as planned use of the investigation in future teaching.

Resulting analysis of both quantitative and qualitative data indicate that mobile learning activities support student learning in various ways that align with the 12 principles of mobile learning (Heick, 2015) and self determination theory (Deci, Vallerand, Pelletier, & Ryan, 1991). Outcomes of this research include a discussion of evidence demonstrating alignment with the 12 principles of mobile learning and self determination theory as well as plans to modify current instructional practices to further support student engagement in future iterations of this course.

Keywords: Mobile learning, self determination, student engagement, online learning, LMS.

INTRODUCTION

Student learning through online activities is nearly universal across institutions of higher learning. Online learning through a college or university system occurs when students and instructors leverage the tools and resources of the internet to engage in real-time and asynchronous communication and learning (Means, Toyama, Murphy, Bakia, & Jones, 2009). Learning Management Systems (LMS) are one way that colleges and universities support student learning in the online environment.

A LMS provides a space to engage in a virtual learning space and is a repository for course assignments, learning materials and other course artifacts. In addition to the use of LMSs, instructors employ varying instructional techniques in order to

engage students in learning within the online environment. Mobile learning, or learning that occurs anytime or anywhere with the aid of a mobile device like a smartphone or iPad/tablet (Wang, Wu, & Wang, 2009), is a subcategory of online learning that includes strategies or techniques that an instructor might employ to engage students in online learning.

Google Drive is cloud based system that provides users with a space for the creation of original materials as well as storage of nearly any type of electronic file. There are numerous applications associated with the Google Drive storage system. One of the most notable Google Drive applications is Google Doc, a web based word processing tool. While Google Doc has familiar word processing functions, this application has added capabilities including web accessibility as well as a sharing function that allows a document creator the ability to collaborate on projects with others. By leveraging the web-based nature of Google Drive, instructors can facilitate mobile learning because students can access, create, modify and collaborate with one another.

FRAMEWORK FOR RESEARCH ON MOBILE AND ONLINE LEARNING

In order to determine the impacts of online and mobile learning, it is necessary to evaluate the effectiveness of the strategies and techniques employed during course activities. The two frameworks used to evaluate the effectiveness of the online and mobile learning activities in this research are self determination theory and the 12 principles of mobile learning. Each of these frameworks are described and connections to this research are discussed.

I would assert that one goal of any education program is lifelong or self determined learner. Self determination theory posits that autonomy, competence and relatedness are central human needs which should be considered when thinking motivation for learning (Deci, Vallerand, Pelletier, & Ryan, 1991). Autonomy or self-determination "refers to being self-initiated and self-regulating" (p. 327).

Autonomy is integral to online and mobile learning because it happens asynchronously; learning happens anytime and anywhere. Online learners have a certain level of autonomy based solely on the learning environment. As an integral component to learning motivation, increased autonomy could be leveraged to increase student performance.

"Competence involves understanding how to attain various external and internal outcomes and being efficacious in performing the requisite actions" (p. 327). Competence speaks to the human need to be able to do or perform things correctly and with confidence. While educators understand that competence is a goal of learning, we also know that learning is an iterative process that often involves mistakes or indirect paths.

The human need to demonstrate competence is both a blessing and a curse. While competence is desired, it does not always happen on a timescale that is compatible with the learner or educational system. In the online learning environment,

competence can be achieved by providing learners with iterative learning activities.

Finally, relatedness "involves developing secure and satisfying connections with others in one's social milieu" (p. 327). Relatedness speaks to the human need for social connections. Relatedness can be challenging in the online environment because physical proximity is a limiting factor. Instructors in online environments need to attend to the need for relatedness. In order to support social connections between students in an online environment, instructors should carefully plan opportunities for both formal and informal student interactions.

The 12 Principles of Mobile Learning (Heick, 2015) also provide a framework for evaluating the impacts of online and mobile learning. The central focus of these principles is that mobile learning "is about self-actualized personalization" (n.p.). The 12 principles can therefore be used as a tool for evaluating the effectiveness of mobile learning tools and strategies. Depending on the use and coordination of the system tools, any of the 12 principles of mobile learning can be supported through the effective use of a online and mobile learning strategies.
Five of the 12 principles for mobile learning are of interest for this research. Three of these principles span between the LMS and Google Doc. A LMS and Google Doc both provide a space for

- ✓ **asynchronous learning,**
- ✓ **cloud access and**
- ✓ **transparency of material. Additionally, Google Doc provides a place for**
- ✓ **play and**
- ✓ **authentic learning.**

In this article, the aforementioned principles of mobile learning (e.g., a-e) as well as self determination theory are contextualized within the scope this research and implications for student engagement are explored.

ONLINE LEARNING VIA A LMS

One of the ways in which colleges and universities support instruction in online environments is through the use of a LMS. A LMS serves "as the course hub for management and administration, communication and discussion, creation and storage of materials, and assessment of subject mastery" (Lang, Leah., Pirani, Judith., 2014). Online learning is asynchronous; providing both time and space for learning that is personally optimal (Harasim, 1996). Asynchronous learning is one of the benefits online courses and one of the "most powerful principles of mobile learning" (n.p). Given that asynchronous learning affords students with a personalized space for learning it is the responsibility of the instructor to take advantage of the anytime, anywhere opportunities for learning (Heick, 2015). An instructor in an online course needs to be certain that the materials and tools for learning a particular topic are available and accessible through the LMS.

In addition to asynchronous learning, a LMS provides a Cloud space as a centralized learning hub that provides a learning environment for students' discussions, storage space for course materials and a repository for uploading student learning artifacts. Finally, a LMS also provides learners with transparency with regard to

course activities. Discussion boards in particular provide students with a forum for sharing ideas between those within the course. Unlike traditional classroom discussions where only a percentage of students voice their ideas, online discussion boards integrate the voices and ideas of all students because participation is linked directly to course evaluative measures.

LMS research is varied and investigates the impacts of LMS tools on student engagement, satisfaction and learning. The results of one study conducted with teacher education students and associated faculty members suggests that participants valued the transparent and cloud-based nature of the LMS used by their university (Heirdsfield, Walker, Tambyah, & Beutel, 2011). Participant survey responses expressed that access to lecture notes, library resources, homework assignments as well as immediate connections with the instructor and other students were the most valued features of the LMS. Additionally, the research participants expressed that the LMS "discussion forum gave them more contact with other students and thus helped them to feel part of a learning community" (Heirdsfield, Walker, Tambyah, & Beutel, 2011, p. 6). In a separate study that investigated engagement of university students in an online information technology/digital literacy course, the results indicate a correlation between access rates of course materials and student grades (Murray, Prez, Geist, & Hedrick, 2012). Students who accessed the course materials with greater frequency earned higher grades that those who accessed the materials less frequently. Results from these studies suggest that the transparent capabilities of cloud based LMS platforms are both valued by students and can support student learning.

MOBILE LEARNING VIA GOOGLE DOC

Similar to a LMS, using Google Doc as a mobile learning tool that supports asynchronous learning, Cloud access and transparency. The asynchronous nature and Cloud access of Google Doc are possible because Google Drive is a web based storage tool for electronic files (i.e., photos, word processing documents, videos) that is accessible anytime and anywhere as long as there is internet access. Transparency is an optional function of Google Doc that is realized when the owner of a Google Doc chooses to share their work with others. For the purposes of collaboration and feedback, using the sharing function for viewing, commenting and/or editing offers a learner the opportunity to express their ideas in real-time as well as receive feedback from others who have been provided access (Slavkov, 2015).

Google Doc also provides an authentic space for learning as well as a space for play; two additional principles of mobile learning. Authentic learning is an integration of all of the Principles of Mobile Learning (Heick, 2015) resulting in learning that is real, tangible and useful to the student (Revington, n.d.).

An example of authentic learning in education courses that can be supported through the use of Google Doc is the development of instructional materials that can be implemented in the classroom.

In addition to having the capability of providing authentic learning, Google Doc also affords a learner with a space for play. By varying the purpose, an instructor can provide a learner with a space for the integration of various external resources, collaborators and unplanned activities within Google Doc. For example, the document history of Google Doc provides users with a place to plan, draft, edit, revise, review and revisit their work. Nothing in Google Doc is ever lost. Anyone with access can view the authentic journey or evolution of the artifact that has been created.

Research on the use of Google Doc in educational settings has demonstrated student engagement in both authentic learning and play. A common use of Google Doc is for the development of student writing. In a quasi-experimental study conducted on two groups of university students enrolled in an English writing course, the group that used Google Doc for writing demonstrated significantly higher writing scores than the control group who received face-to-face instruction on writing (Suwantarathip & Wichadee, 2014). Students in the Google Doc group collaborated with one another, requiring students to read as well as provide feedback to other student's writing. The researchers assert that these activities supported further development of students writing capabilities beyond that of their control group counterparts. Student engagement in the various stages of the writing process aligns with both authentic learning and play. Because the writing process is iterative and best evolves from the input and feedback of others, the students in the Google Doc group experienced a learning experience that better aligns with the authentic writing process of a professional writer.

In a study conducted with upper elementary students, a teacher who engaged students in the creation of their own textbooks explains how the use of Google Docs along with other tools supported students in authentic learning (Encheff, 2013). Google Docs was used for writing, collaborative editing and storage of the content that was finally placed into eBooks developed by the students. Based on the student development of the eBook, students reported feeling proficient with the use of different tools that they used; include Google Drive and Google Doc. Given that these skills, and others associated with the project, are transferable to different types of learning situations the eBook experience was authentic. Given the appropriate scaffolds, the use of Google Doc for learning can support both student play and authentic mobile learning.

PURPOSE

While research on online learning techniques is abundant, further research on mobile learning is needed that investigates the impacts of these techniques with different populations. Further investigation of mobile will provide necessary information about the most effective strategies for meeting the needs of different learners.

This research is to investigate the impacts of mobile and online techniques with a population of preservice teachers enrolled in a science methods course. While the bodies of literature on online and mobile learning continue to grow, research on preservice science teachers using mobile learning strategies is limited. This research serves as an opportunity to begin filling in this gap in the literature.

One of the primary functions of an education methods course is to engage students in practices associated with the field. In the case of a science methods course, learning experiences involve engagement with science and engineering practices. The intersection of science/engineering practices and mobile learning will provide a platform for the investigation of student engagement in this methods course. The purpose of this research is to investigate how mobile learning activities facilitate the scientific investigations in an online methods course.

METHODS

This research employs a mixed methods approach, using both quantitative and qualitative data. The data that I harvested to analyze student engagement related to science investigations, specifically mobile learning activities, include the student's' observation journals, weekly responses to the LMS prompts, and the exchange of ideas between students that occurred within these two spaces. In both of the online learning spaces I calculated the number of:

- ✓ **Replies/comments made by peers on comments or ideas;**
- ✓ **Replies made by the course instructor (me);**
- ✓ **Replies provided back to peers by the student who originally posted;**
- ✓ **Extended discussion sequences (2 or more comments/replies to an idea or comment); and**
- ✓ **Total participants involved in the conversation.**

With these data, I then ran statistical analyses to determine the average number of these activities for both of the learning spaces. Additionally the student journals and LMS dialogues were analyzed qualitatively for themes in order to reveal activities indicating engagement in mobile learning activities.

Participants

Thirteen students were enrolled in the 10-week online science methods course during the Winter 2015-2016 term. Twelve of the 13 students completed all of the course activities and comprise the participants whose data were used to evaluate the science learning activities. Two of the 12 students were male and the remaining students were female. All of the participants are working toward their licensure in elementary education.

Science Learning Activities

Using the construction techniques and materials described in Bottle Biology (Ingram & Kelley, 1993) the students were instructed to create a decomposition column during the second week of the course.

Along with the construction of the column, students were directed to create an observation journal using Google Docs in a shared course folder created in Google Drive (Moreillon, 2015). In their online journals, students were guided to create a data table within which they would collect data about three measureable variables. Additionally, the participants were instructed to include one photo of their

column per week along with their written observations. Table 1 is an example of a data table created by one student.

Table 1.
Sample decomposition column data.

Date	Time	Height of compost pile (Centimeters)	Water drainage (Milliliters)	Growth of bean? (Centimeter)
Jan. 22 2016	8:00pm	(not measured 1st day)	1 ml	0
Jan. 28, 2016	8:30pm	29.7 cm	1.5 ml	0
Jan. 29, 2016	8:45pm	29.7 cm	2 ml	0
Jan. 30, 2016	2:00pm	29.7 cm	2 ml	0
Jan. 31, 2016	12:20pm	29.7 cm	2.2 ml	0
Feb. 1, 2016	7:38pm	26.6 cm	2.3 ml	0
Feb. 2, 2016	9:00pm	26.6 cm	2.2 ml	0.76 cm
Feb. 3, 2016	7:45pm	26.6 cm	2.2 ml	1.2 cm
Feb. 4, 2016	6:25pm	266.7 mm	2.3 ml	5.8 cm
Feb. 5, 2016	5:40pm	26.6 cm	4.1 ml	12.7 cm
Feb. 6, 2016	2:15pm	26.6 cm	4.1 ml	16.5 cm
Feb. 9, 2016	7:37pm	25.4 cm	5 ml	17.7 cm
Feb. 11, 2016	8:00pm	25.4 cm	5 ml	17.9 cm
Feb. 13, 2016	12:03pm	25.4 cm	5 ml	19 cm
Feb. 15, 2016	3:00pm	24.8 cm	5 ml	20.3 cm
Feb. 17, 2016	8:05pm	24.8 cm	0.5 ml	20.3 cm

Once constructed, the students collected their first set of measureable data and added that information to their data table.

The students were directed to collect data three or more times each of the 4 weeks of this activity as well as write a narrative describing any thoughts,

questions, ideas and/or observations about the decomposition and/or growing process.

The students' online journals were housed in a shared course folder and students were prompted to read and comment on the observations and ideas of their colleagues using the "comment" function within Google Docs.

Students were also prompted weekly to comment on their investigation activities through the course LMS. The weekly prompts posted on the LMS about the decomposition columns were:

- ✓ **Week #2 - Comment on the construction process. What are some of the challenges that you encountered? What are you looking forward to during this investigation? What initial ideas do you have about the process of decomposition?**
- ✓ **Week 3-5: Post any thoughts or comments you have about your compost column to this discussion board.**
- ✓ **Week 6: Reflect upon your compost column experience; review your journal, review the journals of your peers, review the discussions that have occurred about the compost column experience. What have you learned from this experience? Write a 2 paragraph reflection about any learning that has occurred connected to your column investigation that includes at least 2 things you have learned from this experience.**

RESULTS

The results are divided between analysis of the data from the LMS and the online observation journals.

LMS Dialogues

The results of the data analysis for the contributions provided to the LMS can be seen in table 2. The data analysis of online dialogue during week 2 that occurred through the LMS revealed that on average:

- ✓ **Slightly more than three peers provided replies to each initial student post;**
- ✓ **Students provided nearly two follow-up replies to comments made by their peers;**
- ✓ **I provided comments to half of the students ;**
- ✓ **Each dialogue stream had at least one extended conversation;**
- ✓ **The total number of comments/replies made to the post for each student was greater than five; and**
- ✓ **More that a 25% of the students (3.5 students) in the course participated in each of the dialogue streams.**

Analysis of the online LMS dialogue from week 3 indicates an increasing trend for dialogue between students. In fact, during the four weeks conversation about the decomposition columns, week #3 was the high point for student dialogue within the LMS. During week 3, on average:

- ✓ **Slightly more that four peers provided replies to the initial comments made by students;**
- ✓ **Students provided slightly more than two responses made to the replies given;**
- ✓ **My contribution to the conversation decreased, including less than 25% of the students;**
- ✓ **Each dialogue stream had more than one extended exchange;**
- ✓ **Each student received nearly 9 replies to their original comment; and**
- ✓ **Almost five peers contributed to each of the dialogue streams.**

Table 2.
Analysis of LMS of Communication Activities.

Week	Replies by peers	Replies to comments/ question by student	Replies by teacher to student post	Extended dialogue	Total number of comments bypeers/teacher in thread	Number of peers participating in dialogue
2 Mean	3.33	1.92	0.58	1.17	5.75	3.58
3 Mean	4.17	2.17	0.17	1.75	8.83	4.75
4 Mean	3.36	2.00	0.09	0.36	3.90	3.40
5 Mean	3.58	1.33	0.33	0.75	4.83	3.67
2 Mode	4	2	1	1	4	4
3 Mode	3	1	0	2	3	3
4 Mode	2	2	0	0	2	2
5 Mode	4	0	0	0	5	4
2 Total	40	23	7	14	69	43
3 Total	50	26	2	21	106	57
4 Total	37	22	1	4	39	34
5 Total	43	16	4	9	58	44
2 Range	0-6	0-6	0-1	0-3	0-14	0-7
3 Range	2-8	1-5	0-1	0-3	3-26	2-9
4 Range	1-7	0-4	0-1	0-2	1-11	1-7
5 Range	0-8	0-5	0-1	0-3	0-12	0-8

Bolded items indicate highest participation in LMS dialogues for different categories.

During weeks 4 and 5 the dialogue returned to levels similar to week 2 with a measurable drop in the number of extended conversations.

During the final week of the decomposition column investigation each student contribution had, on average, less than one extended exchange between students as well as fewer that four replies and four participants in each conversation.

There was fluctuation in the level of student engagement in the LMS conversations. Perhaps because the prompts did not vary during weeks 3-5, the students became bored with the LMS discussion and focused their engagement within the observation journals.

Observation Journal Dialogue

There were no weekly assignment boundaries associated with comments that the students were expected to make about the observations of their peers. The observation journal was a living document during the 4 weeks of this investigations and because of that conversations could and sometimes did extended across multiple weeks.

These conversations that expand beyond the boundaries of weekly assignments are in contrast to the conversations that were held in the LSM.

Because conversations extended beyond weekly boundaries, the data from each of the journals could not be counted by week, but was calculated, instead, as totals the different activities (i.e., number of replies, number of comments, etc.). These totals were then used to calculate weekly averages.

The results of the data analysis of the online observation journal activities can be seen in Table 2.

Table 2 shows that each student had an average of three logged observations in their journals each week.

This average aligns with the observation journal assignment parameters. On average nearly four comments were made by peers to each set of weekly observations per student and each student participant replied nearly 3 times to those comments.

The number of replies to comments was in the online journals was measurably higher than the number of replies given in the LMS conversations. On average, I provided each student with more than one comment each week and received replies back to those comments at almost a rate of 1-to-1.

On average, each student had more than one extended discussion each week. Students also had an average of five photos in their journals.

These five photos, approximately 1/week, align with the assignment parameters. Approximately seven students contributed comments to each journal over the four weeks of the activity with nearly two students contributing to weekly comments.

Table 3.
Online Observation of Journal Activities.

Measure	4 Week Mean	Total for 4 Weeks	Per Week Average of Entire Group	Weekly Average per Student
# replies by all students to peers	11.83	142	35.50	2.96
# replies by student to instructor	4.42	53	13.25	1.10
# of initialcomments from peers	15.42	185	46.25	3.85
# of initial comments from instructor	6.83	82	20.50	1.71
# of extended discussions (2 or more replies to a comment)	6.33	76	19.00	1.58
# of entries made over 4 weeks	12.17	146	36.50	3.04
# of photos over 4 weeks	20.08	241	60.25	5.02
# of participants who contributed comments	7.08	85	21.25	1.77
max # of comments or replies by a peer	7.17	86	21.50	1.79
min # of comments or replies by a peer	1.08	13	3.25	0.27
average # of comments by a participant	3.09	37.08	9.27	0.77

Qualitative Analysis

Through content analysis of the dialogue from the LMS and Observation journals, I identified several themes aligned with student engagement in mobile learning activities. The activities that I identify as mobile learning include:

- ✓ **Construction of the decomposition columns;**
- ✓ **Photos of the decomposition columns;**
- ✓ **Three or more observations of column investigation each week;**
- ✓ **Decomposition columns being kept outdoors - expected due to the nature of the activity;**
- ✓ **Engagement of participants outside of the course (e.g., friends and family) - not planned;**
- ✓ **Some students replicated the column investigation - not planned;**
- ✓ **Discussion of planned implementation of course related activities in future classrooms - not planned, but desirable; and**
- ✓ **Modified current/future practices - desirable.**

Some of these mobile learning activities were planned into the investigation while other were not. Each of these mobile learning activities will be described and examples will be provided.

Planned Mobile Learning Activities

There were several mobile learning activities that were planned for the column investigation. Construction of the columns was is one of the obvious examples

of mobile learning that was planned for this extended investigation. While the students were provided with instructions, including diagrams, the construction process required students to collect materials and problem solve when they were unable to follow the instructions. One example of a student who struggled collecting materials and was able to problem solve is Deb (pseudonym). Deb tried to find a reasonable substitute for nylons which are used to cover openings in the column. Deb indicated her problem solving strategy when she said,

"I didn't have stockings either and I didn't want to purchase some just to cut it up, so I went to Payless Shoe Store to see if they had Peds (it's kind of like a thin sock), but all the ones they had were too thick in my opinion. Luckily, after I told the lady at the store that I needed something with the thinness of a stocking for my science project, she gave me the unused stockings they give to customers when they try on shoes (for free)." (Deb, LMS Dialogue 23 Jan 2016)

While the task of construction is challenging, the students who struggled with this task did so because they had anxiety about building the column "correctly". Cara (pseudonym) articulated her feelings about the construction in this way, she said "I am worried that if I do something wrong that I won't get a good grade or be able to get good results" (Cara, LMS, 23 Jan 2016). While the anxiety of construction is not idea for the students' it does provide an optimal space for learning and growth. During the construction of the column, the students were challenged. The construction activities required them to think critically about the process and solve problems; an ideal scenario from the perspective of instructor.

By providing written instructions that are open to interpretation and requiring the collection of materials as well as column construction, the students are required to find solutions to problems. The collection of materials and construction of the column was a challenge for many, but exemplifies extended engagement as well as mobile learning. The students demonstrated mobile learning when they to collected the necessary materials and build the column away from their computers and then reported on the progress and process as part of their LMS and Journal dialogues.

Another example of mobile learning are the photos that were added to the students' observation journals. While these photographs were integrated part of the assignments, students were able to make their learning mobile when they made observations in the moment and then shared those observations with others in their journals. The photos provided opportunities for students to engage in dialogue about their columns, something that might not have been as engaging without the photos to compare.

Students were also required to make multiple observations of their column each week. While required, these several observations necessitated that students engage with the investigations in an ongoing manner. The multiple observations provided a foundation for rich discussions in both LMS and Journal spaces.

Using shared Google Drive folders as the repository for the observation journals was another intentional instructional choice that was made to promote mobile learning. By using a shared Google Drive folder, my intention was to have students compare and discuss their investigations in a shared learning space. This space

was meant to be intentionally different from the LMS dialogue because it was created to be a living document that would provide formative information about the students activities and developing ideas. Using a shared Google Drive also provides students with the opportunities to include various file types that might not be easily linked to the LMS platform.

Unplanned mobile learning activities

There were several mobile learning actions that occurred that were unplanned during the decomposition column investigation. Many of the students chose to keep their column investigation materials in an outdoor location. By moving learning outdoors, engagement with the activity became extended and mobile. Students who kept their columns outside were engaging in learning while outside conducting their observations as well as during their online dialogues with peers.

Because these activities were conducted in their own homes, several students indicated the inclusion of other individuals beyond those enrolled in the class in the decomposition investigation. Students involved spouses and children in their investigation activities. One participant described it this way; she said "[m]y husband and kids were part of this creation so it has become a bit of a family project now" (Abby (pseudonym), LMS Dialogue, 23 Jan, 2016). With the inclusion of others in course activities the opportunity for learning is expanded through the sharing of ideas and the communication of those ideas back to the course group. This is an example of mobile learning because the learning has extended beyond the planned recipient.

During the investigation, several students were dissatisfied with the outcome of their primary investigation and chose to replicate the experiment; making modifications to the original design or variables in order to achieve a more desired outcome. One participant described her motivation to rebuild this way; she said "[a]lthough the death of my plants was discouraging, it has greatly helped me in planning my reconstruction and learning from my mistakes. (Abby, Observation Journal, 20 Feb 2016). Students were not prompted to engage in this behavior, but were supported by me in their efforts. These actions exemplify mobile learning because the students were self-motivated to investigate the phenomenon further in an effort to increase their understanding.

Throughout the investigation, students asked questions that were not able to be answered by the group. Whether the question was about the construction of the column or the activities occurring during decomposition, the students in the course did not feel as if they had the necessary information to answer those questions. In response, several students chose to access external internet resources in an effort to answer those questions. Deb indicated that she used Google to search for an answer when she said, "I Googled it, and found an answer from HGTV.com". (Deb, LMS Dialogue, 27 Jan 2016). Similarly, Abby indicated that she search outside sources for information when she said,

"After doing some research, I wish I would've done some things differently. For example, I read that it's better to crush the eggshell and scatter grass clippings to keep them from clumping. I also read that turning your compost pile is

recommended. I'm debating on whether I should try turning it." (Abby, LMS Dialogue, 31 Jan 2016)

In the instances when students accessed external resources they engaged in mobile learning. These students extended beyond the materials provided in order to become more informed. Their questions and the questions of their peers motivated the need to pursue answers.

Finally, several of the science methods students indicated their intention to, or the direct application of the activities associated with the column investigation. Some students indicated that they planned to incorporate a similar investigation into future classroom activities with their own students, while others indicated that they were using the experience in their current classroom activities. Brandi (pseudonym) described her desire to incorporate the column investigation in this way, she said

"I will definitely incorporate this lesson into my class one day. I feel this will be a great learning experience for my current and future students. I believe the students will have a ton of fun constructing our compost column, having the responsibility of taking care of it (watering it) and making observations as it slowly changes. I look forward to making a lesson on this in the near future" (Brandi, LMS Dialogue, 19 Feb 2016).

Deb described that her experience with the column investigation was impacting her classroom practices and what she was teaching. She said

"This has allowed me to not only reflect on myself and my learning process, it has also allowed me to really listen to my students and acknowledge their opinions and their learning process. I learned that in order to keep a plant alive, they need sunlight and water. This is something that corresponds with the second grade standard that I have been teaching my students about" (Deb, LMS Dialogue, 20 Feb 2016). While it is always desirable to provide students with learning experiences that apply to real-world situations, that is not always possible. It appears that as if this investigation is mobile because it is directly applicable to learning experiences that can be modeled in K-6 classrooms.

Results from the data analysis would suggest that the decomposition column investigation provided learners in this online science methods course with an engaging learning experience that was supported by both planned and unexpected mobile learning techniques. Multiple weekly journal entries, the inclusion of column photographs and the variability of construction were planned mobile learning experiences that provided a foundation for students to engage in unplanned mobile learning. These unplanned mobile learning activities included accessing external resources, the inclusion of outside participants (e.g., family members) and repeating the investigation.

DISCUSSION

The results indicate that the decomposition column investigation and associated activities completed by students pursuing their elementary teaching license utilized mobile learning techniques to facilitate their engagement in

science/engineering practices. The planned and unplanned activities associated with the 4-week decomposition column investigation demonstrated evidence of alignment with both self determination theory (Deci et al., 1991) and the 12 principles of mobile learning (Heick, 2015).

Students enacted planned mobile learning techniques including the use of the university LMS, Google Drive, photographs, construction of the column, and multiple observations per week. Students enacted unplanned mobile learning techniques when they accessed external resources to further inform their investigations, conducted additional trails of the column investigation, and engaged others in the investigation process.

12 Principles of Mobile Learning

Through both the planned and unplanned activities, the students demonstrated five of the 12 principles of mobile learning. The five mobile learning principles enacted during this research were: asynchronous, cloud, transparency, play and authentic (Heick, 2015).

The activities aligned with investigation were based in the cloud and were asynchronous. The investigation journals and the associated dialogue were housed in cloud-based spaces (i.e., Google drive & LMS) and were available to students 24 hours day. Students reported observations and made comments about the observations of their peers in an anytime and anywhere fashion in both of these learning spaces.

The LMS and Google Drive learning spaces also afforded transparency, opportunities for play as well as an authentic experience. The LMS and Google Drive were transparent because all of the content, materials and dialogue were visible to everyone within the learning community.

I employed the share function when creating all of the course folders in Google Drive providing an opportunity for every participant the chance to see what others were reporting. Similarly, in the LMS, course activities, materials and dialogue were visible for all to see at any time. Evidence of play and authentic learning were primarily a function of the investigation journals. Because data collection happened in Google Doc, evidence of play and authentic learning were more clear. Photographs provided evidence of play, particularly with regard to the construction of the columns.

While students were provided with instructions, their interpretation of those instructions and the lack of instructor input provide a space for students to play with the idea of construction including the materials for the column as well as the composting materials within the column.

Authentic learning was evident when students reported that they had accessed external resources to assist with the development of their ideas or that they planned on using this activity with their students in the future.

While not all of 12 principles of mobile learning were present in this

investigation, there was evidence that five of the principles were being addressed. In the future, I would consider integrating additional principles of mobile learning in order to increase student engagement and learning.

Self Determination

The unplanned learning activities afforded learners with a space to demonstrate two characteristics of self determination; competence and autonomy (Deci et al., 1991). The students who accessed external resources did so autonomous of the course requirements. I would infer that the students engaged in this autonomous behavior in an effort to further develop their understanding of the column investigation. The students who conducted multiple iterations of the column investigation demonstrated the self determination principle of competency. By engaging in the iterative process of conducting the same investigation again, I infer that the students were testing their understanding of the investigation activities in order to be confident in their understanding of the processes involved. Not all of the students accessed external resources or repeated the investigation. While not a requirement of the investigation, these behaviors align with the desire for students to be lifelong self-motivated learners. Therefore, I need to consider how best to foster these behaviors while maintaining authenticity.

CONCLUSION

This investigation was designed to investigate how mobile learning activities facilitate the scientific investigations of students in an online science methods course. Analysis of data from both the LMS and Google Docs indicate that learning was facilitated as much if not more by the unplanned mobile learning activities than those that were planned. Additionally, the students who enacted unplanned mobile learning demonstrated self determined learning; a desirable outcome for any learning experience. The fact that the student column investigation afforded a space for these unplanned mobile learning activities and subsequent self determined learning is an indicator that even in its current form this column investigation fosters an authentic learning experience.

LIMITATIONS

The dialogues that developed in both the LMS and individual observation journals demonstrated student engagement in the investigation activities, however the communication within the observation journals appeared to be more authentic; the dialogue had the opportunity to extend beyond weekly assignment boundaries. Given the shared learning space available within Google Drive, I might consider using the observation journals as a singular repository for student dialogue about this investigation and reserve the LMS as a space for FAQ's, Problem solving, pedagogical questions, resources and troubleshooting.

Transparency about the function of each of the learning spaces will increase if the dialogue in either Google Doc or LMS is focused on a particular topic. By increasing transparency in these two spaces further topics relevant authentic learning about science teaching can be considered (i.e., pedagogy, problem solving, etc.).

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