Understanding students’ learning behavior outside of the classroom

Completed Research

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Abstract

Not being constrained to a physical classroom or the time when it has to take place opens up several new possibilities to teachers. However, before a teacher is able to shift learning outside of the classroom it is necessary to know how students behave under these new conditions. This is why we implemented a mobile learning application that monitors students’ activities and gives them the opportunity to interact and reiterate course content at any given time. This was an effort to enhance student-content interaction which is indispensable when it comes to learning. For this purpose, we tried to develop more authentic content which is linked to a specific place. This way we were able to observe that students preferred location-based content that was located closer to the classroom. Furthermore, we were able to observe that students preferred to engage content by late morning times.

Keywords

mobile learning, gamification, interaction, location based learning, context

Introduction

The number of students in higher education has increased in different countries for the last couple of years (Austria 2017; Bundesamt 2017a; Bundesamt 2017b). However, even though enrolment has increased it is desirable to keep class sizes small as it affects the achievement of students in K-12 and in higher education (Glass 1982; Kokkelenberg et al. 2008). This is partly due to the fact that larger classes can lead to an anonymous environment where students are passive and do not interact (Ward and Jenkins 1992). This missing interaction can be crucial in a student’s study as it is essential for all learning. Here we can differentiate between student-teacher, student-student, and student-content interaction (Moore 1989).

In our research we will lay the focus on student-content interaction as content is key to ease and strengthen the learning experience (Castle and McGuire 2010). We will observe students’ willingness to engage content especially in informal settings located outside of the classroom and determine their preferences. For this purpose, we added more authentic content to our regular course curriculum by creating a mobile learning application that uses real-world objects to showcase course content. This is the attempt to offer students something more than the regular teacher-student interaction. How important informal settings can be for mobile learning was pointed out by Clough et al. (Clough et al. 2008). They showed that mobile learners use their devices especially in an informal learning context with a collaborative, contextual and constructivist mobile learning philosophy.

It is our ambition to analyze how and when students actually make use of their mobile devices, when they access learning content, as well as their willingness to do this in an informal setting. Informal and mobile
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Learning studies often rely on diary studies or interviews. These approaches, however, do have some drawbacks when it comes to accuracy. Participants of retrospective interviews, for example, struggle to remember past events which may lead to recall discrepancies (Vavoula and Sharples 2008). In our real classroom setting we chose to focus and evaluate the log data that is being provided by our mobile application to determine students’ behavior. We are especially interested to know when students engage content on their own as well as if they are willing to explore real-life authentic examples. This will hopefully give teachers the opportunity to better understand students’ behavior outside of the classroom and create new teaching methods accordingly.

**Background**

Before we enhance the authenticity of our course content and observe our students’ actions we need to consider the pedagogical perspectives. Here it is important to consider the learning as well as the teaching approach that is going to be used. Afterwards, we need to outline possibilities to make our approach more attractive for the students as we are trying to change their regular behavior.

From a learning theory point of view, in our approach we will look at constructivism as it is being used in the context of mobile learning (Koole 2009). Jonassen et al. say that people who believe in constructivism think “that knowledge is constructed, not transmitted. Individuals make sense of their world and everything with which they come in contact by constructing their own representations or models of their experiences” (Jonassen et al. 1999, p.3). By requiring students to use most of their senses when going through the learning process we can create stronger links between new and old knowledge (Petty 2009). However, this requires us to choose a teaching technique that compels students to use more than just one of their senses.

**Teaching techniques**

There are several teaching techniques that help to convey information to students. In this paper, we will consider the mnemonic method that goes back to the ancient Greeks. By associating objects with information, it is easier for a person to recall specific information when needed (Yates 1966). It has already been shown that students are able to remember more items when using this method than if they used their regular approach (Bower 1970). However, when considering mnemonic techniques there is more to consider than just to link information with an object. For example, there are also other mnemonic techniques such as to create acronyms or acrostics. The former creates a new word from the first letters of the items to remember whereas the latter uses them to create a whole new sentence. Then there is also the Method Of Loci (MOL) that associates items to remember with different locations in a mental map. By passing those locations in memory a person can more easily recall the stored information (Putnam 2015). Briggs et al. (1970) showed that by using MOL 50 of their tested students were able to recall on average at least 17 out of 20 items.

In our approach, we will use MOL but not rely on a mental map as this can be a challenging cognitive task. Especially for inexperienced participants it can be hard to imagine any environment in their minds (Rosello et al. 2016). Instead we will use real locations close to the university campus to make the content not only more authentic, but also less demanding for students to imagine. We used this technique in an undergraduate introductory building history course where students are among other things supposed to learn about structures and building types from the Middle Ages. By using this approach, we can now get students to physically pass medieval items and associate those objects with course content.

**Context-based learning and teaching**

Students are not only often faced with curriculum-overload but they are also having a hard time to organize that knowledge. Introducing context to the design of a course, such as in the domain of chemistry, has shown that it helps students to prevent an overload and further helps them to better mentally organize their knowledge (Pilot and Bulte 2006). Rose defines this addition of context to learning as ”a pedagogical methodology that, in all its disparate forms, centers on the belief that both the social context of the learning environment and the real, concrete context of knowing are pivotal to the acquisition and processing of knowledge” (2012, p.799). By providing context it is the desire of a teacher to give more authenticity to the
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subject. This will get students actively involved with the material which is the most important aspect that influences learning (Campbell et al. 1994). Berns and Erickson (2001) define contextual teaching and learning as "a conception of teaching and learning that helps teachers relate subject matter content to real world situations and motivates students to make connections between knowledge and its applications to their lives as family members, citizens, students, and workers". It wants to (a) enhance problem-solving skills, (b) be located in multiple contexts, (c) get students to take charge of their own learning in order for them to become self-regulated learners, (d) adapt teaching and learning to fit into the different contexts of each students' life, (e) get students to work and learn from each other, (f) "and employ authentic assessment" (Sears 1999, p.4).

When it comes to the context or rather the place where learning might take place Forster and Hoffmann (2016) differentiate between a place, a Point of Interest (POI), and a Point of Learning (POL). A place is able to foster learning. However, if this is an arbitrary place then this is up to chance. A specific POI, on the other hand, has motivational aspects that helps learning when it comes to deliver simple information. It is not bound to chance. Lastly, a POL delivers more than just information. It fosters specific knowledge structures that have been created in combination with a specific place and technology that enables participants to engage content. They further give advice on what to consider when creating location-based tasks for students. Among other things, they should (a) be relevant to the learner in a way that adds value compared to the mere information, (b) be reachable, (c) offer feedback, (d) and have an authentic and realistic learning goal (Forster and Hoffmann 2016).

In this paper, we will create multiple POLs using our app. We will allocate them at different locations in the vicinity of the campus and ask students to answer location specific questions. Students are able to see the map in the app, as seen in figure 1, with all POLs they are able to visit. The app tracks their GPS location and unlocks the respective questions once they are in the close vicinity of the POL. One example of such a location-based question would be to count the columns of the central nave in a cathedral. The floor plan of the cathedral, as seen in figure 2, is accompanied by an introductory text. In this example, we tell the students that the cathedral is split into eight areas and that the red part represents the central nave. How a cathedral is structured is part of course content knowledge. To answer the question a student is required to enter the cathedral, find the appropriate area and then count the columns. Afterwards, students are able to select the correct answer from a list of multiple choice answers. The goal is to get students to recognize elements of such a structure when they are actually on-site.

**Diurnal efficiency**

Besides motivation it can also be necessary to account for personal preferences to make the experience as pleasant as possible. Researchers have shown that the time of the day has an effect on the mental performance of an individual. Gates (1916), for example, found out that memory and association capabilities are different throughout the day. Further research has also shown that age plays an important role when it comes to the ability to concentrate throughout the day (Klein 2001). It has therefore been argued that since
concentration also has an effect on school performance (Ammons 1995), it is necessary that school schedules need to be adjusted. This way students can take tests when they are best able to concentrate (Callan 1998; Klein 2001).

However, choosing to adjust to individuals’ preferences would require teachers to determine the circadian type of their students ahead of time. Fortunately, several questionnaires have been developed such as the ChronoType Questionnaire (Roenneberg et al. 2003), or the Morningness-Eveningness Questionnaire (MEQ) (Horne and Ostberg 1975) to determine an individual’s specific circadian type. In our research, instead of having our students fill out questionnaires and disturb the regular classroom activities, we will rather evaluate our data to estimate which kind of circadian type they are.

Research Approach

In order to scientifically evaluate our approach, we chose to use the Design Science Research (DSR) methodology. It not only tries to “address important unsolved problems in unique or innovative ways or solved problems in more effective or efficient ways” (Hevner et al. 2004, p.81), but it also “creates and evaluates IT artifacts intended to solve identified organizational problems” (Hevner et al. 2004, p.77). The definition of DSR took some time and required work from researchers from within IS as well as other disciplines. Shortly after the work by Hevner et al. (2004), which was a key contribution to the field, Peffers et al. (2006) continued the work and concerned themselves with the creation of a conceptual process as well as a mental model for it. The process was later split into six steps which starts with the identification and motivation to solve a given problem. The following step is to set objectives that are part of the new solution. The third step is to start the design and development which is then followed by its demonstration. The last two steps are comprised of the evaluation of the findings and finally their communication. They further propose four different research entry points that vary depending on the reasons for undertaking the research (Peffers et al. 2007). As we wanted to determine how students behave while acting outside of the classroom and using that knowledge for future research we made use of their objective-centered approach.

For this purpose, we created an artifact in the form of a mobile app. We implemented it natively on the two major mobile platforms iOS and Android in order to reach about 99% of smartphone users (Smartphone OS Market Share 2015). With the app we want to determine whether it is feasible to enrich a classroom experience with real world examples, as well as ascertain how students adapt to this new form of lecture.

Approach

We developed and implemented the app to allow teachers to create and send out questions to their students. In its functionality it is very similar to a Classroom Response System (CRS) with the addition of location-based capabilities. This means that questions are either location independent, meaning it is only necessary to subscribe to a course to receive them, or they are location aware. In the latter case, students need to visit a predetermined location in order to receive and answer given questions. We use these sorts of questions to showcase the course content of our introductory building history course which is intended for architecture students. In this course, we asked questions that were concerned with ancient buildings, building types, building techniques, as well as building theory.

A teacher is able to create different POLs which in our case are a set of coordinates that mark a certain location and contain questions relevant to them. In this specific course we marked things such as bridges, churches, or ancient buildings. Only when students visit this POL and enter a predetermined radius surrounding it, they are able to get access to and answer questions associated with it. A teacher is able to add a POL at any coordinate on a given map.

The goal is to enhance course content, observe students’ behavior and progress, and deliver a new practical approach that is a mixture of formal and informal learning. Teachers make use of an iOS tablet implementation of the App to create questions and evaluate student answers. Students, on the other hand, have a smartphone app for iOS or Android that receives questions and allows to answer them. If the answer was correct a student is awarded points for solving it. These points are then aggregated and shown in an anonymous ranking that is both accessible to the students as well as the teacher. This approach of integrating
game elements in a non-game context is called gamification (Deterding et al. 2011). The usage of our app was voluntary, which made it important that it is as persuasive and enjoyable as possible. For this purpose, we used the motivating capabilities of gamification to further compel and motivate our students to participate. Students are able to access and receive those type of questions after they have downloaded our app and subscribed to the specific course. We further relied on the Bring Your Own Device (BYOD) approach instead of providing each student with a loaner. This benefits our institution as we don’t have to buy expensive hardware as well as it ensures that students always have the app at their disposal and are already familiar with the device they are using.

Questions were further made available to students through the university’s Learning Management System (LMS) to account for students who chose not to take part or did not have access to a compatible smartphone. The LMS at our institution is part of each course and can be used for things such as making course content material available. This way we made sure that no student was at a disadvantage if they were not using our app for any given reason. We made the app available to the students at the beginning of the semester and evaluated their logged data at the end. Students were aware of the fact that anonymized data was collected when the app was actively used. We were especially interested in comparing students who chose to visit POLs and how these students compared to the rest of the class. To keep the circumstances as realistic as possible we did not control the usage of this new technology nor did we force anyone to use it. This is the approach that is also taken with the LMS. The first lesson was used to show the functionality of our app as well as its installation.

Evaluation

For this course, we defined twelve POLs at the beginning of the semester with 30 questions to unlock. Besides these questions we also asked 113 questions that did not require students to visit a specific place. We had a total of 265 students (45% male, 55% female) who registered for the class using the university’s LMS. Out of these students 63 did at least visit one POL. In comparison, 142 students chose not to visit any POL but still participated in answering non-location-based questions (regular questions). About 22% of the students chose not to use the app at all. In this paper, we will continue to compare two student groups. The first group are students who did discover at least one POL (group 1) whereas the second group is composed of students who only answered regular questions (group 2).

Once a teacher has made a question available to the students they are able to answer them as many times as they want to. The same holds true for any location-based question once a student has visited the corresponding POL. This falls in line with regular practice to make course content material available to students so that they have access to it at any given time and as often as they want to. However, points for answering questions are only awarded for the first given answer. Any answer given by a student, be it a repetition, or the first answer, will be logged by the system. We will differentiate between two activities. The first one is the action to answer regular questions. We call this question activity. Here the user is actively participating or reiterating course content. The second one is the POL activity. This is when a user visits a predefined POL from the course in order to unlock a set of questions associated with that location.

First of all, we will look at the question activity between both groups. In order to compare both groups, we will neglect the unlocked location-based questions and just take into account the regular questions, as these were accessible by all students. It is our goal to see if there are any significant differences between both of them. Out of all the recorded 19137 answers during the entire semester we saw that group 1 answered on average 133.02 questions with a standard deviation of 119.06. This compares to group 2 who chose to answer on average 75.52 questions with a standard deviation of 84.83. This includes first answers and any repetition they submitted. We will, furthermore, take a look at the average points which were reached by answering questions correctly. For this part group 1 did on average score 174.90 points with a standard deviation of 113.93, whereas group 2 averaged 96.51 points with a standard deviation of 88.52.

Figure 3 gives an overview on which days each group was the most active in answering regular questions. Thursday is the day where both groups are almost equally active. For the remaining workdays it is group 1 which is more engaged. On the weekend, however, group 2 is considerably more active. It is important to mention that we held weekly classes that took place every Thursday from 11:30 o’clock to 13:00 o’clock.
In addition to the breakdown in weekdays we will also look at the time during the day when most students submitted their answers. Looking at figure 4 shows that both groups behaved similarly. Most of the students seemed to have been active during the time of 10:00 o’clock till 22:00 o’clock.

Figure 3. Question activity during the week

Figure 4. Daytime question activity

Now instead of comparing both groups we will take a closer look how group 1 behaved while exploring the POLs. Figure 5 shows a distribution when POLs where visited by students. The figure clearly depicts that Thursday has been the most active day for users. In contrast to that Sunday has seen the least activity. Looking at the hourly weekly distribution when POLs were visited, figure 6 shows us that an afternoon/evening time was preferred by the students. The peak where most students chose to visit a POL was between 16:00 o’clock and 18:00 o’clock. Night and early morning times seem to be the least popular time for engaging POLs.

Figure 7 offers an overview of the actual completion rate of visited POLs. As can be seen, only two students visited all twelve of them. On average 5.16 POLs were visited by group 1 members with a standard deviation of 3.92. Another thing to notice is the relationship of a POL being visited and its distance to the classroom. Figure 8 depicts the number of visits by a participant and how distant that POL is from the classroom. A negative relationship can be observed.

Discussion

The gathered data shows us that most of our students were willing to participate and learn in informal settings. We are satisfied with our result that so many students participated and are confident that even more students would have used the app if its usage was mandatory. Students who chose not to use the app did not provide any reason for not participating as they were not required to. Both figure 3 and figure 5 show the daily distribution of when either questions were answered or POLs were visited. The most noticeable
part is the distribution. Even though in both cases there is a clear peak in activity for the day of the lecture we can still see lots of activity for the remaining days. Only Sundays show almost no activity when it comes to POL visits. This might be caused due to different reasons. One possible explanation is the circumstance that on a Sunday shops are typically closed in the country where we performed our study. Not being able to combine visiting a POL and go shopping, for example, could lead a student to remain inactive. We therefore concluded not to expect a high completion rate for weekends. If these findings prove to be consistent over different courses and different situations then educators should rather rely on weekdays for students to seek out POLs.

Taking a closer look at figure 4 and figure 6 further reveals the most common activity time for either answering questions or visiting POLs. Both show a low night and low early morning activity. The essential time of operations for both seems to be approximately from 10:00 o’clock to 22:00 o’clock. This is a good indicator that we have not just one circadian type of student but rather different ones. This should be considered by a teacher when creating POLs located in an area that is restricted by opening hours. Making sure that students are able to visit POLs at any time should ensure a higher completion rate.

Considering that almost the entire week is being used for learning is encouraging. This means that students are willing to participate and work beyond the classroom. With this knowledge, a teacher could now spread learning content over several different days. This will avoid cramming everything into the specified class time. The approach to distribute learning is called spaced learning and has already shown to be more effective than trying to learn everything in a massed approach (Carpenter et al. 2012; Cepeda et al. 2006). This allows teachers to achieve better memory retention among their students without having to increase learning time (Rohrer and Pashler 2007). However, the challenging part is going to be for teachers to initiate learning while students are not in class. If they are able to reach students and initiate learning from a distance then a more spaced approach is possible. This could disrupt traditional teaching by shifting classes away from taking place on a specific day in a specific location to rather multiple days with shorter duration in different places.

The difference of reached points and answered questions between the two groups is noticeable. We credit their high standard deviations to the fact that some students show a constant interest into participating and gaining points and that some of them lose interest once they have participated. Using the Mann-Whitney-Wilcoxon test we saw a significant difference between group 1 and group 2 when comparing the amount of questions, they chose to answer (W = 5830.5, p-value = 0.0005339). Since we are observing a real life setting we credit this difference to the fact that only the most ambitious students actually went on to discover POLs and chose to answer more questions. This would explain why group 1 performed better in terms of points than group 2 on the same set of questions. For educators in general this can be a good method to find engaged students in larger learning environments. This knowledge can especially be useful if teachers want to assemble balanced study groups.

Finally, figure 7 as well as figure 8 show how many students actually visited the POLs. We can see a tendency of the participants to visit less of them the farther they are located. The Spearman correlation between
distance and visits does furthermore, indicate that there is a strong negative relationship (rho -0.762565, p-value = 0.006351) between the variables. We think POLs that are located closer to the classroom profit from the fact that students are already in their proximity when attending class. Furthermore, a teacher might also raise students’ motivation to visit a POL or remind them to do so. However, other factors such as distance to the city center or the distance from a student’s apartment might also influence their visits. For future courses this means to place the POLs as close to the classroom as possible.

To summarize, we can say it is necessary for educators to plan the distribution of POLs as carefully as they would classroom courses. Distributing POLs requires educators to determine a location that is not too remote, easily accessible, and relevant to the subject. A location, for example, that is generally relevant to any student is the library. It offers further research material that can be useful for any given subject. Educators can make students easily aware of its location and highlight further reading material. However, it is necessary to offer an engaging experience that shows students the benefits of this approach. For this purpose, it is necessary to explore if other gamification elements might be useful to increase participation.

Limitations

Due to the observation in a real life setting there are several limitations to consider. As we already mentioned, since the POLs are located outside of the classroom, there are several variables to take into account. One of them would be the weather. Different weather circumstances could easily lead to different results. We performed this study during our summer semester. Because the winter semester would have implicated lower temperatures as well as the possibility of snow, it is necessary to observe students’ behavior over an entire year and also in different regions and cultures and see if the weather or other circumstances effect the results.

Another influencing factor is the actual position of the POL. Even though the distance between two of them compared to the classroom might be the same, they can still not be considered equal. One of them might be located in the city, where students spend their free time, whereas the other one is located in a more remote location. The latter one would therefore make the experience for students a more intentional endeavor as this would be the sole purpose of their journey. We further considered the classroom as a reference point. However, to get a better impression on how students behave when seeking out POLs it would be more accurate to also use their home address as a secondary reference point. Although, this could lead to lower participation among students as they could feel uncomfortable having to reveal their private information. Since the final exam in the class was detached from our anonymized data collection we were not able to associate grades from the exam with a user’s app performance. In future iterations this connection would be useful in determining whether or not engaged students are also the ones that perform well on the final exam. Furthermore, a student’s schedule and their corresponding free time may also affect the time they choose to participate as well as POL visits. The institution where the study took place mostly only consists of full-time students. Their schedule for the semester might therefore have a great impact on our findings. Part-time students with a different schedule may result in different distributions.

Lastly, it is necessary to remember that all the results have been assessed in a specific context. This includes a set of students from a specific major, a specific time when data was collected, and a specific location. In order to make general recommendations, it is necessary that the results are confirmed by further research which tests its validity by altering the given parameters.

Future Research

In our current research, we looked at how students behaved when POLs and class questions were introduced as part of an architecture course. This kind of setting is especially interesting if there are close by objects such as buildings, or bridges that help to exemplify course content. However, other courses with other priorities might find it difficult to determine POLs that might be of value, or which contribute to the course content. For this reason, we want to shift from a POL that is at a fixed location to a flexible one. Rather than defining specific locations that might add value to the course, we will assign students from within the course the role of a POL. We will teach them specific content which they can then convey to their peers. This will make it easier for a teacher to use almost any subject content. Furthermore, we can make the course even
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more interactive by not only targeting student-content interaction but also student-student interaction. This approach will resemble a peer learning approach where students learn and teach each other. This new case would not be describing a Point Of Learning anymore but rather a Person Of Interest (POI). Nonetheless, if we want to extend the course beyond the classroom, as we have done with our POLs, we need to consider the distance between our students, as they are free to move around. Farther apart students might be as counterproductive to the experience as POLs that are located too far from the classroom. Distance remains an important factor to consider (Forster and Hoffmann 2016).

Conclusion

We observed in our research how students reacted to the introduction of our app. It offered them the possibility to answer questions through their smartphones as well as engage real-world objects outside of the classroom. This was an attempt to make course content more authentic and increase student-content interaction. We are encouraged by our results that almost 78% of the students chose to use our app even though its usage was completely voluntary. On the one hand, it offered us insights on when students tend to interact and reiterate course material and on the other hand, their willingness to seek out learning content beyond the classroom limits. For when it comes to engage course material we were able to see that students prefer late morning till late afternoon times and the day when class was held. This is a good indicator for researchers, developers, and teachers to lay a special focus on this day when trying to get the most attention and engagement. However, we also saw that students used the entire rest of the week to continue their learning effort. This can be of great importance when trying to shift classwork outside of the classroom and try out new teaching techniques such as spaced learning. Lastly, we were able to see a deterioration of POL visits the further they were located from the classroom. Distance, among other things, should therefore be considered when trying to shift course work outside of the classroom.

The initial effort we put into creating our app was quite substantial. However, it does now offer an easy method to integrate material that is located outside of the classroom, make better use of the time between classes, and determine engaged students. This scalable solution is especially helpful when it comes to deal with various class sizes. Overall, we are satisfied with our results and are encouraged that they will help other researchers and developers to plan and create better mobile learning applications. However, even though we were able to differentiate between productive days and hours, more research is still needed to determine how results change in a different environment with another set of students.

References

Berns, R. G. and Erickson, P. M. 2001. “Contextual Teaching and Learning: Preparing Students for the New Economy. The Highlight Zone: Research@ Work No. 5.” ().


Glass, G. V. et al. 1982. “School class size: Research and policy.” ()


