Accepted Manuscript

Usage of a mobile social learning platform with virtual badges in a primary school

Ivica Boticki, Jelena Baksa, Peter Seow, Chee-Kit Looi

PII: S0360-1315(15)00068-8

DOI: 10.1016/j.compedu.2015.02.015

Reference: CAE 2807

To appear in: *Computers & Education*

Received Date: 25 March 2014

Revised Date: 15 February 2015

Accepted Date: 26 February 2015

Please cite this article as: Boticki I., Baksa J., Seow P. & Looi C.-K., Usage of a mobile social learning platform with virtual badges in a primary school, Computers & Education (2015), doi: 10.1016/j.compedu.2015.02.015.

Usage of a mobile social learning platform with virtual badges in a primary school

Ivica BOTICKI
University of Zagreb, Faculty of electrical engineering and computing
Unska 3, Zagreb, Croatia
ivica.boticki@fer.hr*

Jelena BAKSA
University of Zagreb, Faculty of electrical engineering and computing
Unska 3, Zagreb, Croatia
jelena.baksa@fer.hr

Peter SEOW
National Institute of Education, Nanyang Technological University
1 Nanyang Walk, Singapore
peter.seow@nie.edu.sg

Chee-Kit LOOI
National Institute of Education, Nanyang Technological University
1 Nanyang Walk, Singapore
cheekit.looi@nie.edu.sg

*corresponding author

Abstract: This study presents and examines SamEx, a mobile learning system used by 305 students in formal and informal learning in a primary school in Singapore. Students use SamEx *in situ* to capture media such as pictures, video clips and audio recordings, comment on them, and share them with their peers. In this paper we report on the experiences of students in using the application throughout a one-year period with a focus on self-directedness, quality of contributions, and answers to contextual question prompts. We examine how the usage of tools such as SamEx predicts students' science examination results, discuss the role of badges as an extrinsic motivational tool, and explore how individual and collaborative learning emerge. Our research shows that the quantity and quality of contributions provided by the students in SamEx predict the end-year assessment score. With respect to specific system features, contextual answers given by the students and the overall likes received by students are also correlated with the end-year assessment score.

Keywords: mobile learning, virtual badges, informal learning, collaborative learning, self-directed learning

1. Introduction

Mobile learning technologies present an innovation force ready to support on-demand, in-situ and real time learning scenarios. They are already being utilized in a number of initiatives around the globe (Chen, 2013; Hargis, Cavanaugh, Kamali, & Soto, 2013). The ubiquitous nature of such technologies is "personally relevant in terms of topics of interest and capitalizes on learners' location as learners decide what, where, when and whether to learn" (Jones, Scanlon, & Clough, 2013; Munoz-Organero, Munoz-Merino, & Kloos, 2012).

Since digital mobile learning technologies can be used anytime and anywhere, they need to be integrated into learning systems in an unobtrusive manner, engaging and stimulating students on repeated use. This is best reflected in recent studies on seamless mobile learning (Looi et al., 2010; Ngaka, Openjuru, & Mazur, 2012; Russell, Knutson, & Crowley, 2012), where the continuity of the learning experiences across different contexts and one device or more per student ("one-to-one") is advocated (Norris & Soloway, 2004). Seamless mobile learning harnesses the portability and versatility of mobile devices to promote a pedagogical shift from didactic teacher-centered to participatory student-centered learning. Learners learn whenever they are curious and seamlessly switch between formal and informal contexts and between individual and social learning, extending the social spaces in which they interact with each other. Seamless learning is supported by theories of social learning, situated learning, knowledge-building, and should influence the nature, the process and the outcomes of learning.

By viewing technology as a nexus between informal and formal learning environments, we are interested in leveraging motivational aspects that could potentially be a driving force for more sustained learning. We would like to see our students spontaneously engage in informal learning which is either self-initiated or emerges indirectly inspired by the school-based activities (Kupiainen, 2013). Towards this, we designed and built a system called SamEx to support spontaneous or location-activated creation, sharing and discussion of artifacts. SamEx was put to trial use with a cohort of 305 primary school students over a period of an academic year to support and complement the learning of science. In this paper, we discuss the design of SamEx and the analysis of data arising from the student use, and explore the relationships of a number of variables of interest with the summative end-year assessment scores of the students.

2. Theoretical background

2.1. Self-directed learning

Nowadays schools feel a growing need to prepare their students for jobs that do not yet exist. This means teachers have to attend to the difficult tasks of developing meta-level learning and cognitive skills in their learners, in addition to covering the curriculum. One of the key traits of so called 21st century learners is self-directed learning, where students manage the learning process on their own, all from setting their own learning goals to the final evaluation of their own learning (Loyens, Magda, & Rikers, 2008). Self-directed learning is a desirable skill leading to more learning and more time spent on learning (Abar & Loken, 2010) and educators should leverage student motivation, behavioral engagement in the activity and parental autonomy support (Sha, Looi, Chen, Seow, & Wong, 2012) to achieve it.

There is some consensus that self-directed learning can be driven by a certain amount of scaffolding which is either provided by the teacher or supported by technology. Studies show that open-ended platforms such as blogging web sites or assessment-driven e-learning systems (Robertson, 2011) help learners in managing their self-directed learning. Self-regulatory behaviour could be a key element of successful e-learning (Wang, 2011).

2.2. Collaborative learning

The theoretical foundation of collaborative learning draws its roots from the developmental psychology of Piaget and Vygotsky's sociocultural theory (Dillenbourg, 1999). Piaget proposed the idea of cognitive conflict where a child experiences dissonance which is the difference between what the child knows of the world and the new experiences or information. According to socio-constructivist approaches, interaction with the peers can help to facilitate such conflicts leading to the construction of new knowledge. Johnson's Social Interdependence Theory (Johnson, 2003) identifies five elements of cooperative learning: 1) Positive Interdependence; 2) Individual Accountability; 3) Promotive Interaction; 4) Social Skills; and 5) Group Processing.

Webb recommends that educators provide explicit instruction for developing collaborative skills, training the students in interpersonal and teamwork skills such as communication, coordination, problem solving, conflict resolution, and negotiation (Webb, 1995). Student can learn how to explain, give constructive feedback, ask for help and give help to their peers. Dillenbourg suggests embedding roles within tasks and these roles can have complementary knowledge or conflicting viewpoints (Dillenbourg Baker, M. J., Blaye, A., & O'Malley, C., 1995).

2.3. Badges for learning

In addition to formal course credit systems which include standard examinations, there is a growing need for alternate ways of motivating both curricular, extracurricular activities and lifelong learning (Young, 2012). This is especially so in online courses and technology-enhanced learning tools which are used in and out of schools, where teachers need to ensure that students' additional efforts are acknowledged and appreciated. In the computer gaming world, badges are earned to indicate the achievement of certain level of skills, acquisition of knowledge, or participation in an activity.

As one implementation option, badges indicate the achieved competence level as defined by the issuer. For example, the integration of badges into existing software is supported by the Mozilla Open Badge Infrastructure (Mozilla, 2013). In the social media context, they have five social psychological functions: goal setting, instruction, reputation, status/affirmation, and group identification (Antin & Churchill, 2011). Thus, they, as epitomized in websites like Huffington Post and TripAdvisor which reward community effort content moderation via digital badges, have proven useful in applications which traditionally lack credit systems.

Badges are nowadays integrated into numerous educational learning tools (Moore, 2013; Sharples et al., 2013), including Khan Academy, BuzzMath and CodeAcademy. However, there are still doubts on whether and how badge scores contribute to the overall student grade in online learning environments (Hakulinen, Auvinen, & Korhonen, 2013). One study shows that ability and motivation of learners have to be considered when choosing the right kind of badges to be used and the kinds of effect they could have on critical learner motivations (Abramovich, Schunn, & Higashi, 2013). TRAKLA2 confirms that and states more research is needed in balancing the badge achievement criteria so that they maximize beneficial learning practices while minimizing harmful side effects; and to understand why the same set of badges had different effects on different populations (Hakulinen et al., 2013).

In a recent study on gamification and social networking in an undergraduate e-learning system which includes badges, the social networking group of students that actively participated obtained the best results (De-Marcos, Domínguez, Saenz-De-Navarrete, & Pagés, 2014). According to the authors, this suggests that traditional e-learning tools coupled with appropriate methods also foster participation. Students of the gamified group obtained lower participation scores, suggesting that this approach may emphasize competition over collaboration and sharing, thus reducing participation of students. Following this line of thought, another study of gamification (Hanus & Fox, 2014) with badges in a university setting reports on the use of combination of leaderboards, badges, and competition mechanics which did not do not improve educational outcomes and that could also harm motivation, satisfaction, and empowerment. According to the authors, decreasing intrinsic motivation can affect students' assessment scores.

On the other side of the spectrum, another recent study brings promising results and addresses the concerns regarding the negative consequences for motivation. Filsecker and Hickey report on benefits of an educational game for fifth-graders which includes badges: the use of external rewards in the context of such technology-enhanced environments does have a positive effect on learning. Their proposed mechanism for the effect of external rewards focused on the role of students' deeper disciplinary engagement (Filsecker & Hickey, 2014).

Thus, there is no consensus on in which subject areas and how are badges to be used in education. Empirical studies are very rare and the majority of papers is primarily exploratory and proof-of-concept, and do not present rounded mature research studies. What is more, badges are often deeply integrated into specific learning designs, pedagogies and tools, making it even more difficult when it comes to recognizing their actual contribution to learning outcomes.

3. Tools and methods

3.1. Tools

3.1.1. SamEx mobile learning application

SamEx was designed to support self-directed and collaborative learning activities and provides a participatory platform for students to contribute, share, and give feedback (Figure 1). Students can use it to take a picture to collect data or post information they found to be useful for their learning. These postings are shared with other students who can review, give comments and evaluate by giving "Likes" to the contribution.

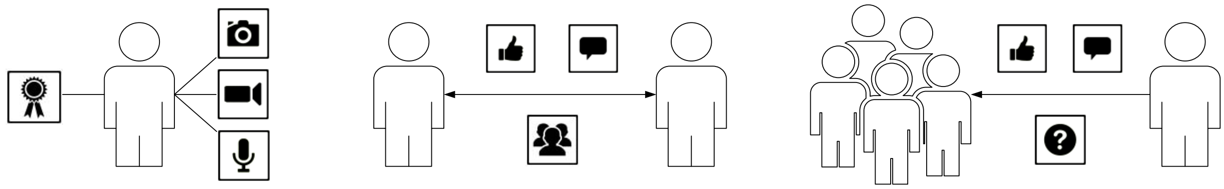


Figure 1. Types of interaction between students and teachers in SamEx

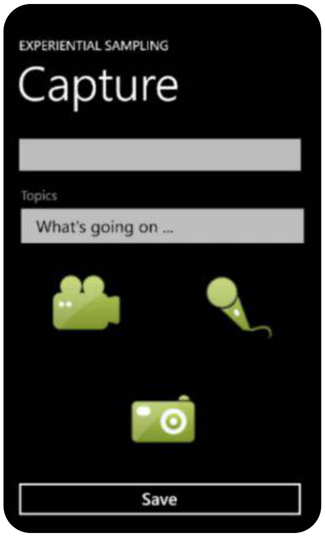


Figure 2. Media capture in SamEx

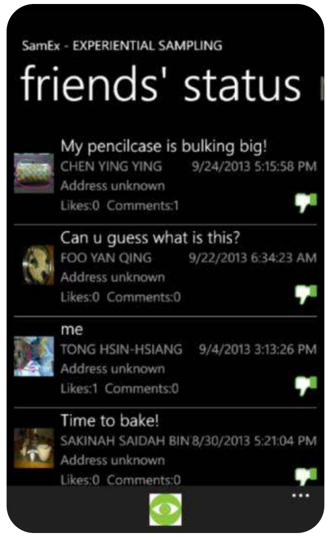


Figure 3. A List of peer experience updates

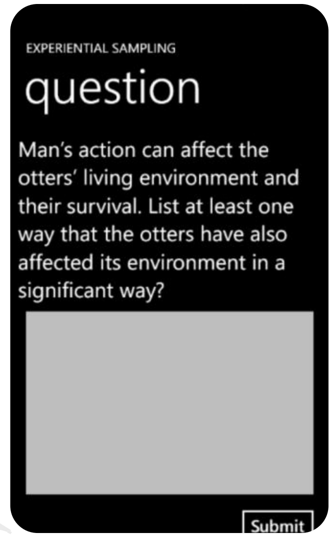


Figure 4. A location-aware question prompt

Figure 5. Following peers' contribution on SamEx

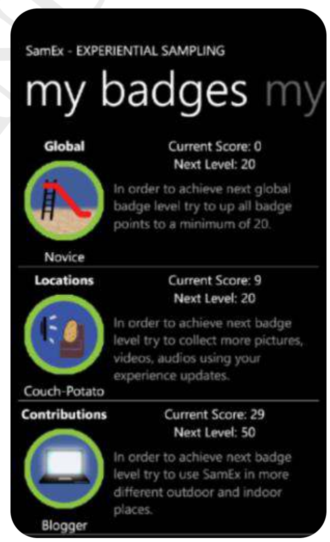


Figure 6. Digital badges in SamEx

For the purpose of this study, activities were designed for primary school students who used SamEx over an one-year period. In addition to collecting, storing and accessing multimedia artifacts (Figure 2), SamEx can store contextual users' information for potential educational use. Depending on the current time and users' location, the system allows question prompts (Figure 4) to be displayed on students' smartphones potentially facilitating or scaffolding learning tasks. Students can therefore be guided in outdoor mobile learning trails or just prompted periodically in connection with their homework observations or other work they are recommended or required to pursue outside school. Students can also subscribe to their peers' contributions (Figure 5).

To reward students' activity, SamEx leverages on its own badge system, an extrinsic motivational tool (Figure 6). By collecting media, answering location-aware questions, providing comments to other students' questions and "liking" other students' work, students take part in a game to accumulate points leading to the earning of badges in five categories with four levels in each category (Table 1). The badges were designed as recognition to motivate student to participate and share in the inquiry process.

Table 1. Badge categories (Answers, Likes, Locations, and Contributions) with badge levels per category

	Low level badge			High level badge
Answers	Shy (Answers>=0)	Knowledgeable (Ans.>=20)	Scholar (Ans>=50)	Genius (Ans>=100)
Likes	Invisible (Likes>=0)	Popular (Likes>=100)	Famous (Likes>=250)	VIP (Likes>=500)
Locations	Couch-potato (Locs>=0)	Tourist (Locs>=10)	Traveller (Locs>=25)	Magellan (Locs>=50)
Contributions	Writer (Contrib>=0)	Blogger (Contrib>=20)	Reporter (Contrib>=50)	Editor (Contrib>=100)
GLOBAL	Novice (initial badge)	Adept (when a student collects level 2 badges in all preceding categories)	Apprentice (when a student collects level 3 badges in all preceding categories)	Professor (when a student collects level 4 badges in all preceding categories)

3.1.2. The underlying technological infrastructure

SamEx was developed for the Windows Phone 7 and 8 mobile operating systems in the Seamless Learning Curricular Innovation in a Singapore primary school. SamEx system architecture consists of the following components (Figure 7): server-side components, web application and mobile clients (Android/Windows Phone applications for smartphone and tablet devices). The system is based on a centralized data model where clients are not responsible for data processing, and thus focus on the interactions with users. SamEx server-side components are: relational database, web application and web services for communication with mobile clients. All three components allow for seamless data storage and administration for both users and administrators. The key issue in SamEx system design is maintaining a consistent state of the data between the server and client applications.

Generic SamEx mobile client application is built of several layers (Figure 8): a server communication service, a data access layer and modules for user interaction (GUI). Data is periodically fetched from the server side and stored locally via a background service. A data access layer is implemented over the storage data structures, allowing developers to make easy structural changes without affecting the application logic for the communication with users.

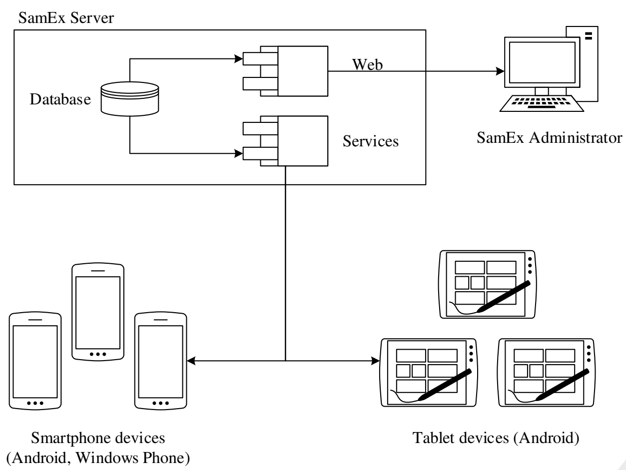


Figure 7. SamEx system architecture

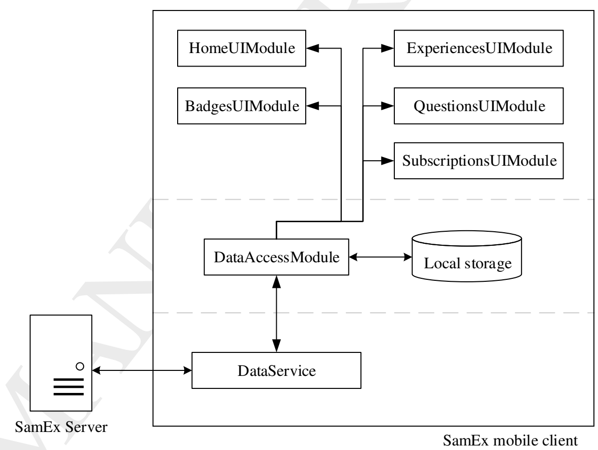


Figure 8. SamEx mobile client architecture

SamEx can be installed on Android or Windows Phone smartphone or tablet devices. Students are given a mobile device with SamEx application preinstalled and preconfigured to immediately act as an active system component. SamEx web application provides an administrative user interface towards the SamEx data. Teachers and administrators are able to search, filter and sort data, and administer student groups or setup location-based prompts (so called “triggered questions”).

3.2. Participants, methods and research questions

3.2.1. Participants and methods

We focus on a whole grade level of primary (Grade) 3 (P3) students who are equipped with 3G smartphones with internet data plans. There are 305 students who were given a mobile device with SamEx mobile application preinstalled and preconfigured for use in and out of school. The school environment is an enticing one, considering the school is one of the Future schools in Singapore and that it focuses on the use of IT in learning. In this study SamEx was used by students both in and out of school and in formal and informal learning activities.

The study employs Design-Based Research (DBR) to develop a deeper understanding of the processes involved in implementing seamless mobile learning. With iterative cycles of studying the processes and outcomes of interventions in building teacher capacity, lesson and technology design, we can refine the processes to develop a program for designing technology enhanced learning environments and develop strategies in and out of the classroom (Phillips, 2006). The phases of the DBR approach along with the initial observation and findings are listed in Table 2.

Table 2. Use of SamEx though five main phases of Design-Based Research

Phase	Research/activity design	Observations and findings
Phase 1A (Pilot phase in the end 2012)	Study a naturalistic process of using SamEx.	Students do not like to be prompted repeatedly for the same question. They are not interested in random sharing of what they were doing/thinking.
This Phase 1B (Pilot phase in the end 2012)	Study a naturalistic process of using SamEx.	The students are interested in location-triggered questions. However, this did not improve their rate of contribution.
Phase 2 (Jan 2013)	Study a naturalistic process of using SamEx. Incorporated badges in SamEx but did not inform the students.	The number of contributions spiked. This is especially so for the higher ability classes. Without being told about the badges, the students explored and figured out how they can attain higher levels of badges.
Phase 3 (Feb 2013)	320 Primary 3 students used SamEx in a combination of indoor and outdoor environment in the Zoo (Figure 10) to learn about animals and plants.	The participation rate is very high. Students across ability levels were able to make meaningful contributions in documenting their observations.
Phase 4 (Feb-May 2013)	Study a naturalistic process of using SamEx to document students' self-directed use of SamEx without further intervention after the Zoo trip.	Subscription to friends' postings and badges without teachers' or researchers' intervention did not encourage the students to make contributions on SamEx. Only a few students remained active in SamEx after the zoo trip.
Phase 5 (June 2013)	Over a 4-week holiday, the students were assigned a task to grow a seed (Figure 9) and discuss the growth of their seed with their classmates and teachers. The students discussed their observations via SamEx.	Usage increased across the levels. Students who did not participate previously contributed actively and meaningfully. Students still do not respond to their friends' questions via SamEx. More students explored the loopholes of attaining higher badge levels by submitting blank posts

Figure 9. SamEx used for a plant experiment (homework): a sample of contributions collected by one student

3.2.2. Co-designing learning activities with teachers – DBR Phase 3

Teachers in the school participated actively in designing the lessons to integrate the use of SamEx into a learning journey at the local zoo. Every year all grade 3 students will visit the zoo to learn about the diversity of the animals and plants by comparing and classifying the different characteristics of animals and plants they observed (Figure 10). The goal was to provide the children with an authentic environment for them to observe different types of animals and plant life in the zoo, and to make connections to their classroom lessons on learning diversity.

After researchers had introduced the main features of SamEx and the teachers experienced its use, the teachers and researchers went on an exploratory field trip to the zoo to familiarise themselves with the environment, identify the learning opportunities in the zoo and discuss the possible learning activities in different parts of the Zoo. In school after the field trip, the teachers discussed the learning activities, the animals and habitats where the students would explore, the route to be taken by the students, and how SamEx could be used to support the field trip. Teachers were assigned different learning stations to design the learning activities such as the tasks to be completed by the students and questions that would be location-based triggered by SamEx as students approached the different learning stations. Tasks included asking the students to observe the characteristics of animals such as the outer covering, take a picture of the animals and describe their observation. Students were asked questions such as comparing the outer covering of different animals and explain the differences based on the habitat they have observed. After the routes and learning stations were decided, the researchers and one teacher created the hotspots where the task and questions would be triggered.

Another exploration field trip was taken with SamEx using the same route students would take and test the accuracy of location-based triggered questions and tasks. The purpose was to test SamEx and understand the learning experiences of the students when they go on the field trip. During exploration trip, the teachers encountered technical constraints caused by the environment. For example, in one section of the learning station, the reception of GPS signal and mobile broadband was extremely poor in the thick forested area. As a result, the location-based task and questions were not triggered. Teachers had to revise the activity and instruction for the activity to proceed. They decided to brief the students on the activity and their tasks before entering the area on the activity. They instruct them to use the camera to take pictures of different animals possessing certain characteristics, and to use SamEx to upload their images when they able to receive better reception outside the area. Teachers took into the consideration the constraints they faced and adapted their design and instruction for the learning activity to achieve the objectives.

Also, the teachers noted that the small screen of the Smartphones and the design of the SamEx did not provide students with an overall detailed view of the learning trail they would be walking, the location of the animals and their habitats, and the student safety instructions. They proceeded to design and publish a learning trail booklet that serves as a guide to each student to supplement the use of SamEx. The conceptualisation, design, planning and implementation of the learning trail with SamEx spanned over 5 weeks during the teachers' regular meeting. Teachers were actively engaged in working with one another and the researchers to explore the environment, to understand the affordances of SamEx, and to consider the learning goals to design a engaging, interactive, and collaborative learning environment for the students.

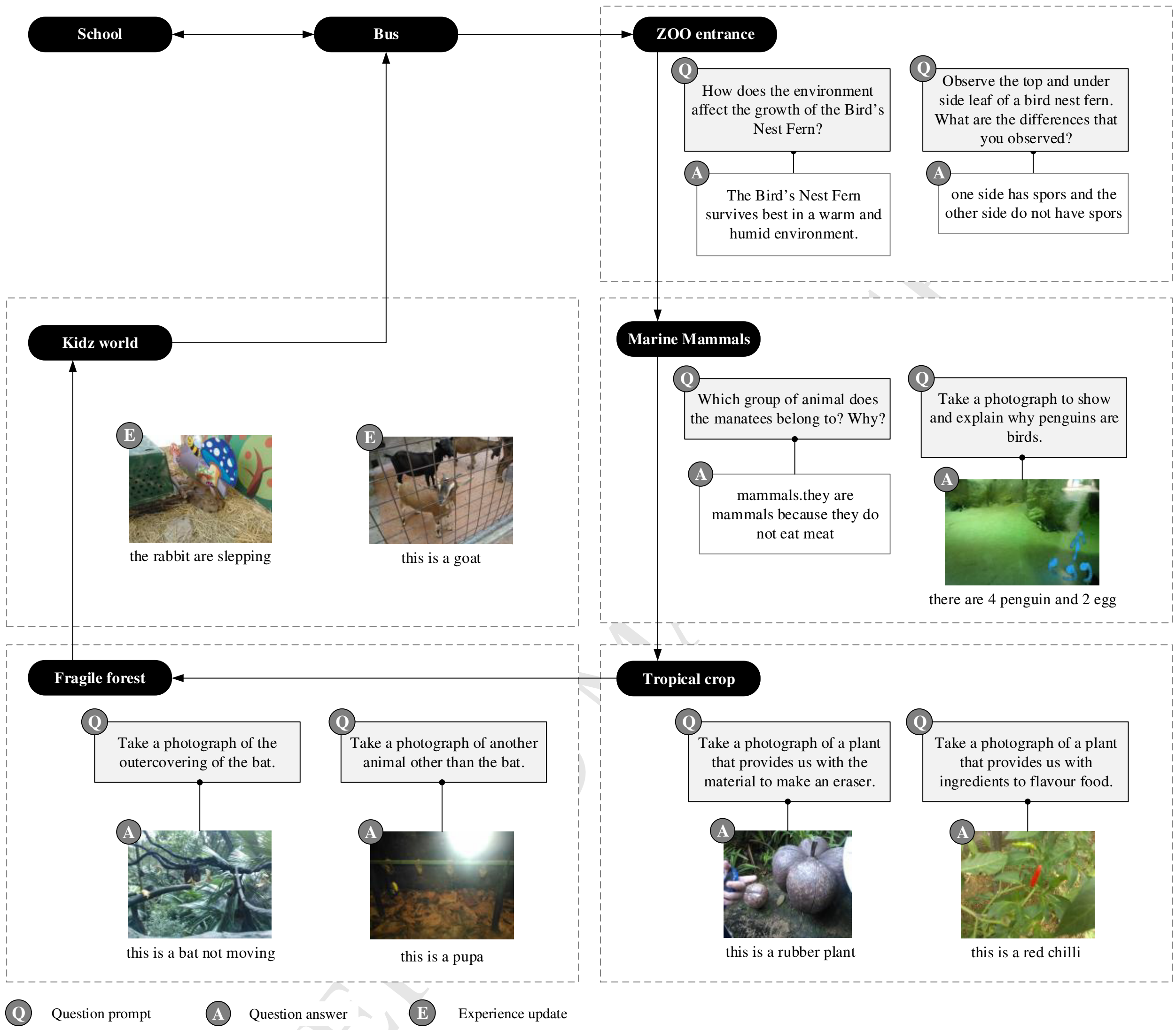


Figure 10. SamEx used in a ZOO trip: a sample of contributions and answers collected by one student

3.2.3. Research questions

Throughout the one-year period our study focused on using SamEx in a variety of in-school and out-of-school learning scenarios. In this study we focus on four main research questions:

1. What is the overall usage of SamEx throughout the 1-year period?
2. What is the relationship between high quality student contributions and the overall student assessment results?
3. Which features of SamEx relate to the overall student exam results? How might SamEx collaboration features predict overall the student assessment results?

4. Does the overall badge score predict student assessment results? What are students' usage patterns in acquiring virtual badges? Do students who show more quality engagement around badges perform better in the exam?

The students did a summative science assessment towards the end of the academic year, and the results of the students' performances on this assessment test are used for the result analysis. The response to the first research question is discussed in the chapter 4.1, while the responses to the rest of the research questions follow in chapters 4.2, 4.3 and 4.4, respectively. The second research question targets only one specific SamEx activity named "The plant experiment", which is further elaborated in the chapter 4.2.

4. Data analysis

The overall usage period can be divided into three stages, which were identified by examining the characteristics of quality and frequency of gathered students' contributions per week (Figure 11).

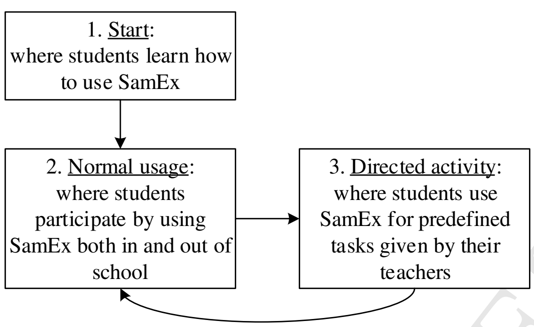


Figure 11. Generalized SamEx usage model

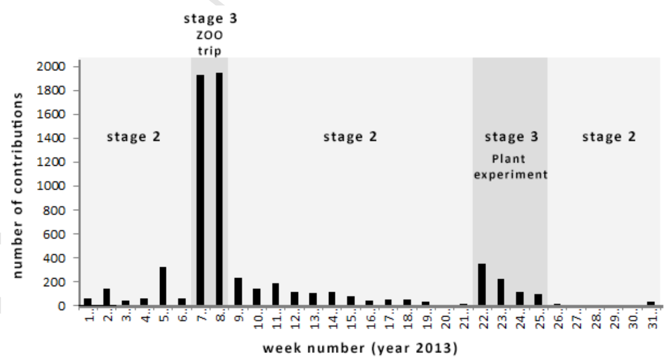


Figure 12. SamEx usage statistics January – July 2013.

The most meaningful and interesting data was detected in Stage 3, where students are given detailed, specific and concrete tasks. In stage 2, the teachers did not reiterate the use of SamEx which explains for the low level of activity. We need intentional task activities to stimulate active use of SamEx to enculturate them into a habit of using SamEx for their own informal learning activities, but our data shows that the students have not yet moved to this stage.

Generally, the quality and number of contributions grew when students were encouraged to focus on specific learning outcomes proposed by their teachers. For example, one of the rich points of overall SamEx usage was the zoo trip in weeks 7 and 8 (Figure 12), where SamEx was preconfigured with explicit location-aware prompts about plants and animals bound to specific zoo locations (so called triggered questions) (Figure 13). They were co-designed by researchers and school teachers to encourage and engage students in observing, reflecting and learning with a focus on meaningful school-related content. The system allows for three types of question prompts to be preset: two categories were designed to simulate conditions on the standard exam: open-ended (type 1) and multiplechoice (type 2) questions. The third group of questions encourages students to document their observations with a picture, video or an audio (type 3).

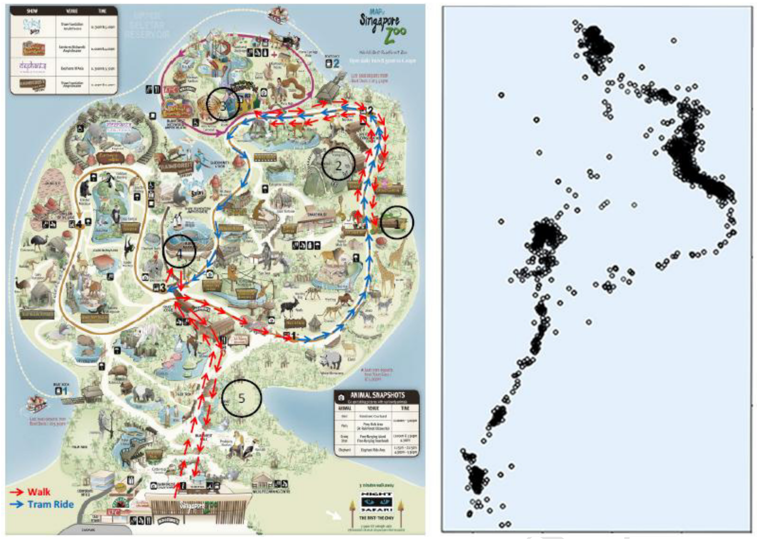


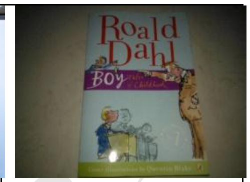
Figure 13. Planned route through the zoo (left), frequency of students' contributions per location (right)

In order to explore the difference between individual and collaborative learners, we analyzed data generated by all P3 classes. Individual learners are identified as the ones generating a large number of contributions at the same time not participating in collaborative activities, such as liking and commenting. On the other hand, students who are more focused on collaborative activities are the ones who explore data posted by their peers, post comments (Table 3) and show appreciation by "liking" a particular artifact (Table 4).

Table 3. Examples of student-to-student and teacher-to-student discussions in SamEx

Student-to-student discussions		**Teacher-to-student discussions**	
Student A:	chilly plant	Student:	the plant is growing
Student A:	u spell chilly wrong! it is supposed to be chilli!!!!!??????	Teacher:	Did you observe anything yet?
		Student:	the other three seeds have not come out, so I put two more seeds in the pot
Student A:	rafflesia		
Student B:	wow!	Student A:	Plant day 3. Nothing yet...
Student C:	It must be very smelly! Be careful!	Student B:	Of course there no plant. It needs about 1 to 2 week to grow...
Student A:	yes, very smelly indeed	Teacher:	Take note of what appears first?
Student A:	There is a centerpide in the. garden!		
Student B:	what type of centerpit?	Student:	Mr Seow , why my plant grow so fast ???
Student C:	is it real???	Teacher:	wow! that is a tall plant Jovin.
Student D:	Does it belong to you?	Teacher:	Did you compare your plant with friends?

Table 4. Examples of student experiences with the most likes

				
-	Sunflower	pencil case	this is our classes the notice board	Roald Dahl, Boy tales of childhood book
11 likes	11 likes	9 likes	9 likes	8 likes

4.1. SamEx usage and its relationship with the students' academic success

Several types of analysis were performed on the student generated data throughout a 1-year period. We focused on the media collected by the students since this was one of the most widely used features of the application (Table 5).

Table 5. Number of analyzed artifacts by category

Category		Count
Contributions	total	7029
	with picture	4724
	with video	340
	with audio	179
Answers to question prompts		3783

Concerning the time students spent on using the system, the average daily usage time for all 305 P3 level students in the 1-year period is 3.35 hours per day, which amounts to 0.66 minutes of use per day per student. There are periods of more intensive use, such as the zoo trip (during 11-25 February), where the total usage for all students is 24 hours per day, amounting to 4.72 minutes per day per student.

We want to examine the relationship between the time students spent on using SamEx and the overall student assessment score. Following very high correlation of these two variables, a multiple linear regression was run to analyze whether and to what extent SamEx usage time predicts the total assessment score. It was found that SamEx usage time statistically significantly predicted the total score, $F(1, 303) = 42.56$, $p < .001$, R2 = .120. usage time variable added statistically significantly to the prediction, $p < .001$ (Table 6).

Table 6. Linear model summary (usage time predicting exam results)

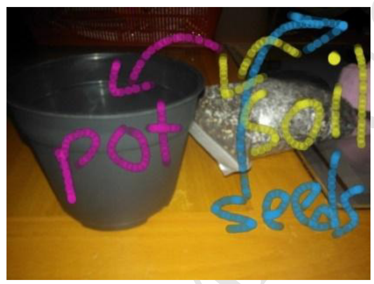
	Model	
Variables	**Beta**	**T-Stats (P-value)**
Constant		60.686 ***
Usage time	0.351	6.524 ***
Total observations	305	
R^2	0.123	
Adjusted R^2	0.120	

*** p<0.001

4.2. How do quality student contributions relate to the academic success

In order to more closely explore the relationship between academic success and quality of students' contributions, we used the data generated by one class in a period of four weeks (Phase 5 in Table 2). Students used SamEx to track the progress of their plant development at their homes, as instructed by their teacher (additionally they were allowed to use the system for their own personally relevant activities). The artifacts they gathered (pictures, audios and videos) were coded and compared with their exam results. The coding was done by two researchers agreeing on the student artifacts (pictures, videos or audios) being self-directed (SD), teacher-directed (TD) or non-meaningful (NM). Cohen's κ was run to determine if there was agreement between two researcher-coders' judgment on whether student experience updates in SamEx were teacher-directed (TD), self-directed (SD) or non meaningful (NM). There was agreement between the two researchers' judgments, κ = .970, $p < .0001$. Examples of coded pictures are shown in Figure 14.

SD (self-directed)
(a student labeled Day 8 of the plant growing and commented with "Day8.My5th plant still needs a stick for support. Why is that so?")



TD (teacher-directed)
(a student follows the task set by the teacher in planting the seed)

NM (non – meaningful)
(a student takes a picture of a TV soap opera)

Figure 14. Examples of self-directed (left) teacher-directed (middle) and non-meaningful (right) student contributions

The analysis indicated surprising and encouraging results: there was correlation between the number occurences of self-directed and teacher-directed behavior exhibited by the students and the overall student exam results. However, a multiple linear regression reveals that only self-directedness (SD) can be used as a predictor variable of the total assessment score, while teacher-directedness (TD) remain insignificant in predicting the overall score. The number of self-directed (SD) SamEx contributions statistically significantly predicted the total score, $F(1, 176) = 8.67$, $p < .001$, R2 = 0.042, with the self-directedness (SD) variable adding statistical significance to the prediction, $p < .001$ (Table 7).

Table 7. Linear model summary (SD predicting exam results)

	Model	
Variables	**Beta**	**T-Stats (P-value)**
Constant		69.554 ***
SD	0.217	2.954 **
Total observations	305	
R^2	0.047	
Adjusted R^2	0.042	

*** p<0.001, **p<0.01

The analysis shows students were able to generate quality contributions both in terms of self-directed (SD) and teacher-directed (TD) content. When contributing teacher-directed content, the students closely followed the instructions their teacher provided and acted accordingly. On the other hand, the students contributing self-directed (SD) content approached their task creatively and took it one step further in delivering the tasks set up by the teachers and combined it with the previous acquired knowledge or even acquired new knowledge in the process. However, it is only self-directed (SD) contributions in SamEx that contribute to the final assessment score, while there is non-significance in the relationship of teacher-directed contributions with the total assessment score.

4.3. SamEx features and their impact on the academic success

Through the data analysis a high number of low-quality artifacts was discovered – i.e. contributions without text description or media and duplicate/similar entries. On a sample of 1500 entries from only one class (out of 8 in total), approximately 25% were flagged as poor quality. One of the possible explanations could be the students' inexperience or lack of familiarity with handling the mobile devices, causing them to submit duplicate or void contributions. Interestingly, there is no significant correlation between the number of low-quality contributions and students' academic success (Table 8).

Table 8. Correlation of academic success with the number of low-quality contributions

		MCQ	OE	TOTAL
Number of low-quality entries	Pearson Correlation	.123	-.033	.066
	Sig. (2-tailed)	.430	.832	.673

Additionally, 15 students (out of 305 in the P3 population) did not contribute a single contribution in SamEx throughout the whole period of the SamEx use. When examining how SamEx features might have predicted students' academic success, we excluded these students from the analysis. After that exclusion, we examined correlation between the following variables in order to identify which ones are appropriate to be included into the multiple linear regression analysis: badge score, number of experience updates posted, answers given, comments given, likes given, comments received and likes received. High correlation was noticed between the badge score variable and all other abovementioned variables due to the fact that SamEx calculates badge scores according to them. Therefore, to exclude the unwanted effect on the linear regression model, we excluded the badge score from this analysis and came up with a multiple regression linear model where the variables answers given and comments received proved significant predictors. In the multiple linear regression, *answers given* and *likes received* statistically significantly predicted the total assessment score, $F(2, 287) = 20.090$, $p < .001$, $R2 = .117$. Two variables (answers given and likes received) added statistically significance to the prediction, $p < .05$ (Table 9).

Table 9. Linear model summary (answers given and likes received predicting exam results)

	Model	
Variables	**Beta**	**T-Stats (P-value)**
Constant		63.793 ***
Answers given	0.141	2.260 **
Likes received	0.262	4.194 ***
Total observations	305	

R^2	0.123	
Adjusted R^2	0.117	

*** p<0.001, **p<0.05

4.4. Badges in SamEx: the story of Dodgers, Badge Hunters, Sharers and Explorers

Another focal point of the analysis is students' usage of SamEx badge system. As it can be seen from the Table 10, the most popular badge category among the students was Contributions, which is not surprising considering the fact that the collection of media artifacts was one of the most widely used SamEx features. Within the Location badge category, a large number of students (204) managed to rise from the first category to the second level. In the Likes category, only 9 students managed to collect level 2 badges. As a consequence, the students did not have much success in collecting Global badges because most of them fell behind in at least one category.

Table 10. Distribution of collected badges by level and category (see category explanations in Table 1)

Level	Answers		Likes		Locations		Contributions		Global	
1	Shy	334	Invisible	357	Couch-potato	154	Writer	216	Novice	360
2	Knowledgeable	30	Popular	9	Tourist	204	Blogger	102	Adept	6
3	Scholar	2	Famous	0	Traveller	8	Reporter	31	Apprentice	0
4	Genius	0	VIP	0	Magellan	0	Editor	17	Professor	0

The first analysis in this chapter tries to identify how badge score predicts the overall student exam success. Similarly to the analysis performed in the chapter 4.3, 15 students (out of 305 in the whole analyzed P3 population) did not contribute with a single contribution in SamEx throughout the whole period of the SamEx use, so they were excluded for this analysis. In the multiple linear regression, the overall *badge score* statistically significantly predicted the total assessment score, $F(1, 303) = 43.413$, $p < .001$, $R2 = .112$. The badge score variable added statistically significance to the prediction, $p < .001$ (Table 11).

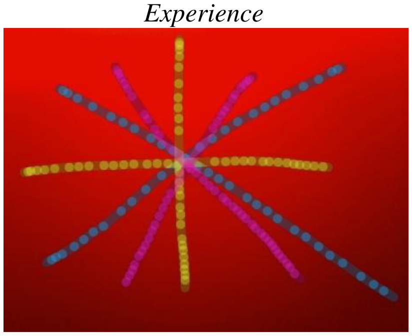
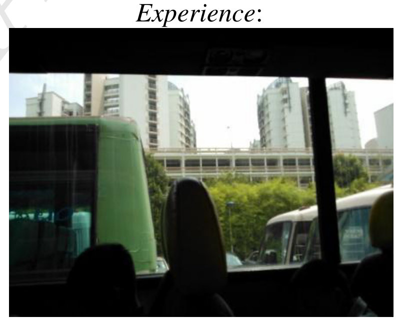
Table 11. Linear model summary (badge score predicting exam results)

	Model	
Variables	**Beta**	**T-Stats (P-value)**
Constant		63.509 ***
Badge score	0.354	6.589 ***
Total observations	305	
R^2	0.125	
Adjusted R^2	0.122	

*** p<0.001

Throughout our studies, we discovered our students belong to the four fundamental groups according to badge system usage: (1) Badge Hunters, (2) Sharers, (3) Dodgers and (4) Explorers (Figure 12). The students were classified in one of the four groups by performing qualitative and quantitative analysis of their media artifacts, answers, comments and likes. We based our decision by closely observing the behaviour patterns for each student in our data sample (8 P3 classes, 305 students). Cohen's κ was run for all 305 students to determine if there was agreement between two researcher-coders' judgment on whether students belong to one of the above mentioned badge categories (Badge Hunters, Sharers, Dodgers or Explorers). There was agreement between the two researchers' judgments, $\kappa = .888$, $p < .001$. Examples of experience updates per each category are given in Table 12.

Table 12. Illustrative examples of posted experience updates for main categories of students according to badge usage (Badge Hunters, Explorers, Dodgers and Sharers)

Badge Hunter	**Explorer**
Experience  <no text> *Number of comments:* 112 (most of them are empty)	*Experience*  although some things can move, it may not be alive. Example, a television. *Comment example:* nice post you got there! *Received likes:* 102
Dodger	**Sharer**
Number of experiences: 3 *Number of question answers:* 3	*Experience*:  outside our school *Number of experiences*: 33 *Number of question answers*: 10 *Received likes*: 65

Dodgers are not interested in earning badges at all, and they are usually easy to notice in the data set. Users with a very low number of posts or no activity at all after the zoo trip all belong to this category. Unfortunately, some students stopped participating after the zoo activity, and despite their initial good effort in using SamEx, they were classified as *Dodgers*. In addition, their usage time is usually much lower than the rest of the group.

Badge Hunters are only interested in attaining high levels of badges and they only respond to extrinsic motivation and do not care about the quality of contributions, which is why they are relatively easy to identify. All users with a very large amount of low quality data over a short period of time (Table 13) belong to this category. Naturally, a good indicator of this category is also a very high badge score. Overall, every student with suspiciously high count of content in some category (experiences, question answers, comments) was closely examined to determine if there was any badge hunting behaviour. For example, a couple of students from one class noticed that they can post unlimited number of comments, and consequently gain points for the badge score. Shortly after that, those users started posting a very high amount of non-meaningful comments, such as sequences of random characters.

Sharers are on the other hand interested in sharing with their peers while earning their badges and their participation consists of higher quality contributions (Table 12). They make meaningful contributions and ask good questions. However, the *Sharers* lack continuity in their postings. They respond incredibly well to any kind of teacher-directed activity, but fail to use the system on their own, unlike *Explorers*. In comparison to the other user categories, they post more than *Dodgers* but less than *Explorers* and *Badge Hunters*. However, the quality of their artifacts is much higher than the *Badge Hunters*. What are also missing in their behaviour are collaborative activities – they are often too focused on themselves and need encouragement to try to learn collaboratively.

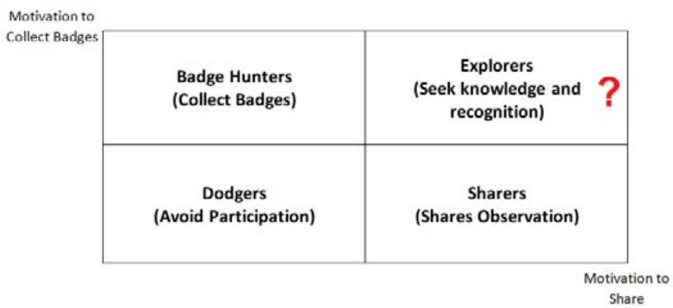


Figure 12. Students according to the impact of badges on motivation, quality of contributions and interest spans

Table 13. Percentage of students in each category for class P3A

Category	%
Sharers	24.26
Dodgers	69.51
Badge hunters	4.59
Explorers	1.64

Prior to examining the overall student exam success, we split them into two main groups according to the assigned badge category: (1) Dodgers and (2) Badge Hunters, Sharers and Explorers. Such a classification was chosen to separate students who did not engage in activities around badges at all from the ones who contributed albeit on a competition basis to collect badges in SamEx. An independent-samples t-test was conducted to compare these two groups of students in terms of academic success. There was a significant difference in the scores group 1 (M=67.25, SD=16.03) group 2 (M=75.46, SD=13.59) conditions; $t(205)=-4.591$, $p < 0.0001$.

As can be seen from the above discussion, a very low percentage of students (Table 13) were placed in the ideal category of *Explorers*. They actively participate in SamEx by generating high quality contributions, sharing their observations, initiating conversations with other students and are trying to gain knowledge collaboratively from their peers. *Explorers* post a lot of content, but unlike *Badge Hunters*, most of their artifacts are meaningful, valuable and sometimes even intriguing. Another rule that separates *Explorers* from the rest of the class is their increased collaborative behaviour. They post encouraging comments, answer questions by their peers and, as a result, receive a high number of “likes” by their classmates. What is even more important, *Explorers* use SamEx at least a couple of times a month, which is much more than the users belonging to the other groups. Consequently, the *Explorers* usually obtain a very high number of badges.

Table 14. Contribution examples for Badge Hunter (all examples are from a single day)

my swing	My pond
my neighbourhood	Potted plants
my balcony	My Living Room
my piano	Bright Light
Fishes eating	Hungry fishes
darkness of doom	tree outside school
My house	outside my house

Table 15. Contribution examples for Sharer (data from a longer period of time)

Can you find the starfruit?	What on earth is that?
Melted chocolate, strawberries and sprinkles...YUM!!!	The biggest balloon(I tied it up too)I have ever blown
There is such a thing as a cotton tree?	Is this a rabbit, kangaroo or a donkey?
Drawing of my dreamhouse! (using pen)	Have you ever seen this in lego before?!
Smallest tree I have ever seen	My first ever rainbow cake!

This means that badges can currently only encourage the first two groups of students to participate. However, Badge Hunters will stop participating once they achieve their desired level of badges. Both Badge Hunters and Sharers are not interested in learning collaboratively since there is no observable learning with their peers.

Nevertheless, it is important to mention that some of the students who were identified as Sharers have a good potential of becoming Explorers. They usually try to learn collaboratively, only to be discouraged by the lack of feedback from their classmates. To help them bridge that gap between Shares and Explorers, all students need to be encouraged to participate more actively, especially in the tasks that involve interaction with their peers.

5. Discussion and conclusion

In this paper we have conducted detailed data analysis of a number of variables mainly describing SamEx usage or SamEx features and tried to find out how these predict the summative end-year assessment score. It has to be noted that although the above analysis comes with medium effect sizes and relatively low value of R square in the multiple regression, its aim was not precise and detailed estimation of the changes in the assessment result due to predictor variable changes. The analysis was rather used to discover usage trends and to get the sense of the designed software features. Based on the analysis that the answers given and likes received predict the total assessment score, from field observations of students using the application, and from focus group interviews with students and teachers, the authors share the strong belief that the introduction of more collaboration software features could impact students' results in the long term and therefore propose extension of the collaborative mobile software components.

Although the SamEx feature functionality allows students to form groups and follow their friends, the students are seldom engaged in group communication and collaboration through the mobile devices. Those users are using all features of SamEx, without a clear preference towards individual versus collaborative activities. In our trials we found out that they actively participated in contributing and sharing their experiences individually. However, we discovered that a small group of students were actively participating in a wider set of SamEx features, despite the lack of engagement from the rest of their class. In order to improve the interaction among the students, they need to be encouraged to participate in collaborative activities. In our design-based research, we have some initial evidence that show that when students engage in such self-directed activities using SamEx, it helps them in their learning. At the same time, in our next iteration of work, we need to improve our learning design to motivate students to continue using the devices as their learning hub on a more sustained basis.

Badges can only motivate students to learn meaningfully when teachers provides the appropriate learning contexts such as facilitating discussions and synthesizing learning points concerning the students' SamEx contributions in class. It provides students a focus in their contribution and helps them relate the contribution to meaning-making. This is shown in Phase 5 where the contribution across the level spiked and more meaningful contributions can be studied. Since students are motivated to contribute artifacts to earn the badges in SamEx, the participation and engagement level of the students would be higher if a group of students works on a common task to collaboratively co-construct higher-level meaning making, such as like adding and elaborating conceptual linkages between using the artifacts created individually.

In our categorization of students in regards to the quality of their engagement around badges, we identified Explorers, who are equally interested in seeking knowledge and interacting with their peers. Design of collaborative tasks for each group that have elements of positive interdependence and individual accountability, and that requires interactions, social skills and group processing (Johnson, 2003) are more likely to foster collaborative learning. In the framework for assessing Collaborative Problem Solving, the tests assess personal competencies in taking initiatives (being proactive), in teamwork, in planning, and in coordination of group work (OECD, 2013) and in social and task regulations (Hesse, Esther, Buder, Sassenberg, & Griffin, 2014), amongst other dimensions of these skills. Considering that these driving principles for creating opportunities for fostering these competencies are related to collaboration, we envisage future designs that can make use of the affordances of the SamEx platform that can capture context and some elements of context (location, time, the surroundings through photo or video capture, etc). The task designs encompass a diverse range from teacher-directed tasks to student-generated pursuits of their own interests and inquiries. Examples of teacher-directed tasks can take the form of: a group of students is scattered in a wide area (like the zoo) and has to collect data or evidence for a common task that requires interdependence, and thus have to coordinate well with each other; versions of this could be (1) The group has limited time to cover the exhibits so they have to split in ones or twos; they have to coordinate with each other to cover as much as possible, and capture images of the exhibits with relevant comments; (2) each student in the group is scattered in location but they need to identify a rendezvous to meet.

In summary, we presented a mobile learning platform that utilizes contextual question prompts, virtual badges and allows for collaborative learning. Since our preliminary analysis of initial work shows that this approach holds some promise, our next research agenda is to continue the designs of learning using SamEx over a more sustained period which will bring about even more learning patterns that allow us to study motivational and self-directed learning aspects of mobile learning.

Acknowledgments

This work has been in part supported by Croatian Science Foundation under the project UIP-2013-11-7908.

References

Abar, B., & Loken, E. (2010). Self-regulated learning and self-directed study in a pre-college sample. *Learning and Individual Differences*, *20*(1), 25–29. doi:http://dx.doi.org/10.1016/j.lindif.2009.09.002

Abramovich, S., Schunn, C., & Higashi, R. M. (2013). Are badges useful in education?: it depends upon the type of badge and expertise of learner. *Etr&D-Educational Technology Research and Development*, *61*(2), 217–232. doi:10.1007/s11423-013-9289-2

Antin, J., & Churchill, E. (2011). Badges in social media: A social psychological perspective. In *CHI 2011* (pp. 1–4). Retrieved from http://uxscientist.com/public/docs/uxsci_2.pdf\nhttp://uxscientist.com/?sort=post_date&page=7

Chen, X. B. (2013). Tablets for informal language learning: Student usage and attitudes. *Language Learning and Technology*, *17*(1), 20–36. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84872872590&partnerID=40&md5=371de875da4782fe373df1548b565c48

De-Marcos, L., Domínguez, A., Saenz-De-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers and Education*, *75*, 82–91. doi:10.1016/j.compedu.2014.01.012

Dillenbourg Baker, M. J., Blaye, A., & O'Malley, C., P. (1995). The evolution of research on collaborative learning. In *Learning in Humans and Machine: Towards an interdisciplinary learning science* (pp. 189–211).

Dillenbourg, P. (1999). What do you mean by "collaborative learning?." In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and Computational Approaches* (pp. 1–19).

Filsecker, M., & Hickey, D. T. (2014). A multilevel analysis of the effects of external rewards on elementary students' motivation, engagement and learning in an educational game. *Computers & Education*, *75*, 136–148. doi:10.1016/j.compedu.2014.02.008

Hakulinen, L., Auvinen, T., & Korhonen, A. (2013). Empirical Study on the Effect of Achievement Badges in TRAKLA2 Online Learning Environment. In *Proceedings of the 2013 Learning and Teaching in Computing and Engineering Conference* (pp. 47–54). IEEE. doi:10.1109/LaTiCE.2013.34

Hanus, M. D., & Fox, J. (2014). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education*, *80*, 152–161. doi:10.1016/j.compedu.2014.08.019

Hargis, J., Cavanaugh, C., Kamali, T., & Soto, M. (2013). A Federal Higher Education iPad Mobile Learning Initiative: Triangulation of Data to Determine Early Effectiveness. *Innovative Higher Education*, 1–13. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84876664500&partnerID=40&md5=048395519a5bc2be205ba30a97189ead

Hesse, F., Esther, C., Buder, J., Sassenberg, K., & Griffin, P. (2014). Framework for Teachable Collaborative Problem Solving Skills Friedrich Hesse, Esther Care, Juergen Buder, Kai Sassenberg, Patrick Griffin. In *Assessment and Teaching of 21st Century Skills Educational Assessment in an Information Age* (pp. 37–56). Springer Berlin Heidelberg.

Johnson, D. W. (2003). Social interdependence: interrelationships among theory, research, and practice. *American Psychologist*, *58*(11).

Jones, A. C., Scanlon, E., & Clough, G. (2013). Mobile learning: Two case studies of supporting inquiry learning in informal and semiformal settings. *Computers and Education*, *61*(1), 21–32. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84867285862&partnerID=40&md5=e91f4ae9529819f411da57078df329f0

Looi, C.-K., Seow, P., Zhang, B., So, H.-J., Chen, W., & Wong, L.-H. (2010). Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology*, *41*(2), 154–169. doi:10.1111/j.1467-8535.2008.00912.x

Loyens, S. M., Magda, J., & Rikers, R. J. P. (2008). Self-Directed Learning in Problem-Based Learning and its Relationships with Self-Regulated Learning. *Educational Psychology Review*, *20*(4), 411–427. doi:10.1007/s10648-008-9082-7

Moore, M. G. (2013). Independent Learning, MOOCs, and the Open Badges Infrastructure. *American Journal of Distance Education*, pp. 75–76. doi:10.1080/08923647.2013.786935

Mozilla. (2013). Open Badges. Retrieved from http://openbadges.org/about/

Munoz-Organero, M., Munoz-Merino, P. J., & Kloos, C. D. (2012). Sending Learning Pills to Mobile Devices in Class to Enhance Student Performance and Motivation in Network Services Configuration Courses. *Ieee Transactions on Education*, *55*(1), 83–87. doi:10.1109/te.2011.2131652

Ngaka, W., Openjuru, G., & Mazur, R. E. (2012). Exploring formal and non-formal education practices for integrated and diverse learning environments in Uganda. *International Journal of Diversity in Organisations, Communities and Nations*, *11*(6), 109–122. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84871529457&partnerID=40&md5=ab52574db9160f85d2bef31e5d3e5aca

Norris, C., & Soloway, E. (2004). Keynote speech. *International Conference on Intelligent Tutoring Systems 2004*. Maceio, Brazil. .

OECD. (2013). Framework for Assessing Collaborative Problem Solving. Retrieved from http://www.oecd.org/pisa/pisaproducts/

Phillips, D. (2006). Assessing the quality of design research proposals. *Educational Design Research*, 93–99.

Robertson, J. (2011). The educational affordances of blogs for self-directed learning. *Computers & Education*, *57*(2), 1628–1644. doi:http://dx.doi.org/10.1016/j.compedu.2011.03.003

Russell, J. L., Knutson, K., & Crowley, K. (2012). Informal learning organizations as part of an educational ecology: Lessons from collaboration across the formal-informal divide. *Journal of Educational Change*, 1–23. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84871120645&partnerID=40&md5=f9eba465aa15fa68535bb5f8096cff5a

Sha, L., Looi, C.-K., Chen, W., Seow, P., & Wong, L.-H. (2012). Recognizing and measuring self-regulated learning in a mobile learning environment. *Computers in Human Behavior*, *28*(2), 718–728. doi:http://dx.doi.org/10.1016/j.chb.2011.11.019

Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., … Whitelock, D. (2013). *Innovating Pedagogy*. The Open University UK.

Wang, T.-H. (2011). Developing Web-based assessment strategies for facilitating junior high school students to perform self-regulated learning in an e-Learning environment. *Computers & Education*, *57*(2), 1801–1812. doi:http://dx.doi.org/10.1016/j.compedu.2011.01.003

Webb, N. M. (1995). Group Collaboration in Assessment: Multiple Objectives, Processes, and Outcomes. *Educational Evaluation and Policy Analysis*, *17*(2), 239–261. doi:10.3102/01623737017002239

Young, J. R. (2012). " Badges" Earned Online Pose Challenge to Traditional College Diplomas. *The Chronicle of Higher Education*, pp. 1–7. Retrieved from http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ1002829

- Answers given and likes received affect the total assessment score
- Introduction of more collaboration software features could impact students' results
- When students engage in such self-directed activities using SamEx, it helps them in their learning
- Badges can motivate students to learn when teachers provide learning contexts
- Intentional teacher-directed tasks stimulate students to participate