

Pre-service teachers' learning and frustrations during the development of serious educational games (SEGs) for learning biology

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Abstract: The purpose of this study is to explore pre-service teachers' learning and frustrations during the development of serious educational games (SEGs) for learning biology. A two-credit, 18-week-long course, entitled *Computers in Teaching and Learning Biology* was offered in fall semester of 2012. A total of 12 pre-service teachers registered in this course –and in-depth interviews with every pre-service teacher were conducted after the conclusion of semester. According to their responses, we found that most of them expressed positive attitudes towards this course but still had some difficulties and challenges in taking this course. Pre-service teachers generally reflected that the instructional time of the course was too short causing that they still didn't really know how to program and code using ActionScript3.0. Discussions regarding the obtained results and suggestions for future work are further provided.

Keywords: Serious educational games (SEGs), pre-service teachers, biology learning, teaching with technology

1. Introduction

It goes without doubt that we are living in a digital era where technology is shaping the way we live, think, and learn. Websites are becoming more important information resources than books and magazines, and we have now online access to tens of thousands learning materials and activities. Moreover, debates about the educational potential of playing video games are decreasing and more than half of the parents now believe that video game play provides mental simulations and is a positive part of child's life (Entertainment Software Association, 2013). As a result, various methods have been created to harness the power of technology to support our education. The use of video games in training and learning environments, known as serious games (SGs) or science educational games (SEGs) (Annetta, 2008), is one of the increasingly relevant trends which transforms our education because new digital innovations has significantly changed our pedagogical perspectives. Supporters of SEGs claim that video games have a huge potential to play as a vehicle for learning and research evidence shows that its positive impact on students motivation, engagement, and learning outcomes seems promising (Cheng & Annetta, 2012; Clark et al., 2011; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Echeverría et al., 2011; Gee, 2003a, 2003b; Giannakos, 2013; Lim, 2008; Paraskeva, Mysirlaki, & Papagianni, 2010; Prensky, 2001; Sánchez & Olivares, 2011).

The use of SEGs is particularly important to science education, as many scientific concepts which are invisible in the real world are generally abstract and difficult to grasp can be portrayed in the virtual world. In addition, scientific inquiry ability and problem-solving skills often require long-term cultivation and repeated practices. The complex structure of science, the trouble of reasoning about abstract concepts, and the challenges that arise in problem solving and scientific inquiry render students a sense of anxiety and difficulties in learning science compared to other subjects (Halff, 2005). However, SEGs which combine game characteristics with science content not only motivate and absorb students in the embedded science learning activities, but also increase the probability of bridging virtual reality into reality in numerous dimensions, providing students with authentic learning wherein they are allowed to repeatedly experience things that are impossible in the real world without worries of real life consequences (Cheng, Annetta, Folta, & Holmes, 2011).

After making a comprehensive survey of literature, we see that most of the available evidence always focuses on students' science learning through SEG play; however, research that emphasizes pre- and in-service teachers' perceptions and implementations of using SEG or their professional development through designing an SEG is comparatively lacking. General people, especially teachers,

always consider creating a game-based learning environment to be expensive and arduous. Moreover, although many governments worldwide have invested money in developing SEGs that facilitate science learning in elementary and secondary settings (eg. <http://www.fas.org/programs/ltp/games/>), accessible resources of SEGs in Taiwan or projects which are funded by Taiwan's government endeavoring to create and develop SEGs are relatively deficient. All of these make it become more challenging and difficult for Taiwanese teachers to integrate SEGs into science classrooms.

Therefore, in fall semester of 2012, a two-credit, 18-week-long course, entitled *Computers in Teaching and Learning Biology*, was delivered to 12 students who are enrolled in teacher education program (pre-service teachers), with an aim to provide these pre-service teachers with an experience of project-based learning (in this case, project refers to the development of an SEG). In this course, students learned Adobe Flash and programming of ActionScript 3.0 and were asked to develop SEGs for biology learning by themselves. They were required to present their SEG idea and script (SEG prototype) in the midterm and demonstrate their SEG in the final. In-depth interviews with every pre-service teacher were conducted and recorded after the conclusion of the semester to collect data regarding feedback and comments towards this course, as well as the challenges and difficulties encountered.

2. Research Design

The course Computers in Teaching and Learning Biology

The course was a two-credit, 18-week-long course. There were a total of 12 students registered in this course. They were finally divided into 4 groups (2-4 individuals/group) to carry the project out by group collaboration. In this course, students were taught basic principles of ActionScript 3.0 programming so that they can use Adobe Flash Player as a platform to demonstrate their created SEGs.

The course schedule can be divided by midterm into two parts. Before midterm (week 1-8), the instructor placed much more emphasis on basic concepts and fundamentals of ActionScript 3.0. After midterm (week 10-16), the instructor in turn introduced specific programming which each group needs according to their SEG script. Two presentations and one paper-and-pencil test were required. Each group had to present game idea and script (SEG prototype) in the midterm (week 9) and demonstrate the SEG (end-product) they created in the end of the semester (week 18). Moreover, there was an exam assessing what they had learned about ActionScript 3.0 in the final (week 17). In addition to in-class practices, five homework assignments were also distributed to ensure that students did learn the programming which was taught. Although the 18-week lectures mainly emphasized the development of programming skills, each group had to regularly discuss their SEG idea and script with a science education expert at times out of classes to ensure the validity of scientific content and pedagogical methods embedded in their games.

Data collection

To explore the pre-service teachers' experiences and reflections on designing SEGs for learning biology, several tape-recorded in-depth interviews with every pre-service teacher were conducted after the semester. The pre-service teachers were asked to answer several leading questions. Each interview with each interviewee lasted about 15-20 minutes. With interviewee permissions, all the interviews were transcribed verbatim into transcriptions for data analysis. These transcriptions were first separated into narrative segments that expressed a specific idea/concept or described a particular experience, and then these narrative segments were again read repeatedly by researchers to find emerging categories. Recurring and qualitative distinct themes, conclusions, and explanations were drawn from these categories.

3. Result

What did the pre-service teachers learn from this course?

Pre-service teachers according to Table 1, pre-service teachers' feedback regarding what they had learned from the course is exactly in alignment with the learning outcomes expected by the instructor. It is surprising to the authors that most of the pre-service teachers may have placed their focus on learning to program with Flash or making games, rather than designing and making "serious educational" games. It may be due to that the fact that the pre-service teachers in this study lacked relevant

knowledge or ability in programming with Flash, hence their insufficient prior knowledge in programming may have distracted their attention during their learning processes. Consequently, they paid most of their attention to programming rather than integrating educational purposes into the games they designed and made.

Table 1: The pre-service teachers' self-reported learning outcomes derived from taking the course (n=12)

Learning outcome	n
1. How to program with Flash	6
2. Designing and making games	4
3. How to design an serious educational game	2
4. Transferring the domain knowledge into a serious educational game	1
5. How to collaboratively work with others	1

The distinctions between the pre-service teachers' expectations and the actual practices of this course?

Table 2 summarizes the distinctions that the pre-service teachers mentioned. Only two of the twelve pre-service teachers expressed that the actual practices of the course were almost the same as what they expected before taking the course. However, the other teachers mentioned various distinctions between what they expected and the actual practices of the course. Most of the pre-service teachers thought that "More efforts should be paid during taking this course." Also some pre-service teachers said that "Making a game is not so easy."

It seems that the workload of this course was too heavy for the pre-service teachers. In particular, for the pre-service teachers without prior knowledge in programming with Flash, as it took them substantially longer periods of time to complete their game design.

Table 2: The distinctions between the pre-service teachers' expectations and the actual practices of this course (n=12)

distinction	n
1. More efforts should be paid during taking this course	5
2. Making a game is not so easy	4
3. Programming with Flash is difficult	3
4. The need for collaboration in making a serious educational game	1

Pre-service teachers' perceptions of their learning processes

As revealed in Table 3, half of the pre-service teachers perceived their learning processes as "interesting and meaningful" or "experiencing student-centered instruction". However, it should also be noticed that other pre-service teachers expressed less positive perceptions regarding this course. In sum, although the loading of the course was heavy, half of the pre-service teachers still had positive perceptions on taking this course. However, others expressed less positive perceptions on their learning processes, suggesting the need for modifying the design and arrangement of this course in the future.

Table 3: Pre-service teachers' perceptions of their learning processes (n=12)

Perception	n
1. Experiencing interesting and meaningful learning	5
2. I spent a lots of time in coding	2
3. Experiencing student-centered instruction	1
4. The loading increased; however, there was insufficient time	1
5. More detailed explanations from the instructor will be helpful	1
6. I could not follow the teacher's instruction	1
7. Lots of homework to be done after school	1

Pre-service teachers' frustrations during taking this course

As shown in Table 4, most of the teachers mentioned that they felt frustrated in programming and coding. Compared with aforementioned frustrations, some teachers expressed their frustrations were caused by further personal commitments. It seems that the more efforts were made by these pre-service

teachers in this course, the more frustrated they might be oriented to feel. These frustrations might be resulted from the pre-service teachers' insufficient experiences of mastering in designing and making SEGs.

Table 4: Pre-service teachers' frustrations during taking this course (n=12)

Frustration	n
1. Programming and coding	8
2. Completing the homework	1
3. How to integrate what I have learnt into the game	1
4. How to implement our design	1
5. Low quality of the game	1

Pre-service teachers' suggestions on instruction

The pre-service teachers in this study provided three major suggestions for the instructor:

- More basic instruction in programming and coding will be helpful.
- More instructional time will be needed.
- Classroom videos and more detailed handouts for students will be helpful.

Pre-service teachers' recommendations on the arrangement of the course

The pre-service teachers in this study also provided three major recommendations on the arrangement of the course:

- The instructional time of the course should be extended.
- The loading of homework should be reduced.
- The participants of the course should be limited.

4. Discussion

Time issue

The insufficiency of instructional time seems the major defect of this course as mentioned. In fact, the curriculum of teacher preparation programs in Taiwan has a rather tight schedule, so that teacher preparation courses related to effective teaching with technology offered by teacher education institutes are relatively few. Moreover, even the courses are offered, almost all of them are elective and two-credit only. Hence, the time issue becomes a dilemma for teacher educators in Taiwan. On the one hand, if the course is offered as a three- or four- credit course, the redundant credit(s) might be not able to be counted into the required credits for graduation. On the other hand, if the course remains two-credit, students might think the difficulty is too great for a two-credit course. Both of the aforementioned situations will significantly decrease students' motivations of taking this course, which clearly reflects the inadequate arrangement of the current teacher preparation courses for improving the technological literacy of pre-service teachers.

Programming issue

Almost all of these pre-service teachers mentioned that they felt frustrated in programming and coding. The major problem is they usually lacked sufficient practices after school and didn't effectively construct an integrated understanding. It is impossible for pre-service teachers or others to gain mastery within a short time period, particularly when the skill in question is complex programming. Substantially more time is required to allow repetitive practice in order to construct an integrated understanding of the execution of computer programs, so that mastery of programming can be gained.

Course loading issue

The criteria for assessing student performance in this course include participation (10%), homework assignments (30%), final paper-and-pencil exam (10%), midterm presentation of prototype (20%), and final demonstration (30%). Despite the midterm presentation of prototype and final demonstration of SEGs that were group work, the five homework assignments and final paper-and-pencil exam required pre-service teachers to finish individually. However, as mentioned earlier that these pre-service teachers are undergraduates who are majoring in biology and are enrolled in teacher education program, meaning that they have to take responsibilities for not only the assignments in this course, but also the

other requirements of the department of biology. Needless to say, the students with biology major would have the tightest course schedule compared to students with other majors since they need to carry out many laboratory experiments. Their feeling was that the course loading was too heavy was therefore natural. Not enough instructional time to allow these pre-service teachers to have sufficient practice in classes again becomes the major issue.

Transfer/integration issue

The transfer/integration issue is difficult, but also important. However, it is frustrating, but not surprising to us, to find that some pre-service teachers still have difficulties in transferring what they have learned into games or completing their games. According to the results, we can see that there might be two transfers/integrations that needed to be taken into account. First is the “transferring/integrating” of their professional knowledge in biology and biology teaching into the game format (integrating scientific concepts, educational objectives, and instructional strategies with game features), and the other is “transferring/integrating” the design of prototype into a real game product. These pre-service teachers showed fewer difficulties in the first transfer/integration after regularly discussing with the science education expert and their group members. However, they were not able to properly transfer the design of prototype into a real game product, even though they might be able to write a very good game script and develop a sound prototype.

5. Suggestions for future work

Offering more credits and instructional time for the course

We think that the credits and instructional time for the course should be increased. After discussing with these pre-service teachers, we figure out that the best way is to offer this course in two semesters, with two-credits for each semester. In the first semester, pre-service teachers will learn the basic programming structure of ActionScript 3.0, the basic ideas of art design, and video and audio making process, and to come up with a sound and detailed game prototype. If more credit hours are offered, their course loading would be significantly decreased.

Cooperating with other professional departments

We highly suggest that this course can be offered as an instruction cooperating with other professional departments, such as the department of computer science and information engineering or management. If there can be cooperation between different departments to offer this course, there would be students with different majors taking it. Consequently, the student groups in this course can be heterogeneous. This kind of heterogeneous grouping is an enhancer of group work because within the group, everyone learns from everyone else, and students are given more opportunities to participate in classes

Providing more scaffolds and social organizations for helping student learning in this course

The provision of more scaffolds is absolutely necessary. The use of exemplary cases is also highly encouraged. For an act or an event, there should be many different methods of programming. If the exemplary cases of programming for the same act/event can be provided, then the pre-service teachers or students can analyze and compare the differences and similarities between two or more examples. Moreover, a large number of websites that provide resources with open codes should be suggested. In so doing, it might be much more helpful for pre-service teachers and students in coming up with their own logic and method of programming. Besides, pre-service teachers mentioned that the in-class instructions should be recorded and saved as tutorial videos. These videos then can be uploaded onto the web so that students could practice and rehearse repeatedly after school.

Administering appropriate number of formative assessments for self-diagnosis and instruction adjustment

Although some participants argued the course loading was too heavy because of so many homework assignments, we still recommend appropriate number of formative assessment should be administrated during the implementation of the course. However, the way it is administrated could be slightly modified. For example, it could be conducted as a format of self-assessment on-line that students decide when and how many times they would like to carry out these assessments. Or the assessments and assignments can be worked on through teamwork instead of being finished individually.

6. Conclusions

The current study explored a group of pre-service teachers' experiences and reflections on a course focusing on learning by designing SEGs. Most of the pre-service teachers expressed positive attitudes towards this course. However, they also mentioned some difficulties and challenges in taking the course. Their experiences and reflections on taking the course provided some important implications for teacher educators and educational game designers. In particular, the suggestions derived from the experience of implementing the course, such as the provision of additional resources and scaffolds for students' learning during this course, would be crucial. Also, it is highly suggested that this course could be offered as an instruction in cooperation with other professional departments, such as the department of computer science and information engineering or management. Consequently, pre-service teachers' learning outcomes as well as the quality of the SEGs they design could be improved.

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