

# Introducing Pre-Service Teachers to Programming Concepts with Game Creation Approach

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**Abstract.** This study aimed to explore whether game creation approach is a feasible strategy for teaching programming concepts to pre-service teachers with no prior programming experiences. Twenty-two pre-service teachers who came from different majors and enrolled in one teacher education course participated in this study. Pre-service teachers were introduced to basic programming concepts and knowledge through instructor's lectures. They exercised and took practices of Scratch game programming. The findings suggest that game creation approach is practical to motivate and engage pre-service teachers in learning programming concepts. Analysis of participants' project code implementation shows that many different fundamental programming concepts have been applied in game project design. Positive attitudes toward game creation approach and programming learning were also revealed in the questionnaire survey results.

**Keywords:** teacher education; game programming; computer science education.

## Introduction

With the rapid development in technology, teaching is no longer just lecturing students. Learning activities incorporating technology might greatly capture students' attention and improve their engagement. Though it is convenient for teachers to draw on commercial educational software, it may not meet their need in classroom. Integrating computing into disciplines via programming provides teachers a better and flexible solution for instructional use. However, there is a general agreement in literature that learning programming is a difficult task for novice programmers (Jenkins, 2002). Moreover, teachers who are usually non-major in computer science have little prior programming background. On the same level, it is also difficult for pre-service teachers to be equipped with standard programming background. One example in the survey of 189 prospective teachers' self-efficacy perceptions on programming (Korkmaz, 2013) revealed that their perceptions on programming are at medium level. Thus, more training and support to improve related programming competence should

be given to teachers. Although the difficulties experienced by novice programmers in learning programming stem from many different reasons, proper programming language and teaching approach might lower their barriers. Teaching novice programmers to learn visual programming with game creation approach may be a practical choice.

## **Related Work**

### **Visual programming**

Visual programming has graphic user interface that enables users to create programs by manipulating program elements such as drag-and-drop. Unlike conventional textual languages that users write programs by typing, visual programming provides an easy and interesting program development environment (Kölling, 2010). Users can effectively create programs in visual interface and inspect their implementation results. It not only can eliminate syntax errors to reduce learners' frustration, but also can facilitate visual instruction understandable to learners thus enhancing their learning outcome.

Being user-friendly, characteristic in visual programming such as Scratch, Alice and StarLogo are suitable to be utilized by K-12 teachers as teaching tools. Conducting visual programming camps or workshops for K-12 teachers to increase programming competence were often reported in research. Scratch having media-rich programming environment is suitable to create games, interactive stories, animations, art as well as music applications (Scratch website, 2015). Bell, Frey and Vasserman (2014) directed a 4 week programming camp for K-12 teachers to explore ways they might incorporate Scratch into their curriculum. The results reveal that teachers have the ability to incorporate their subject matter into Scratch-based classroom activities. Alice, a 3D virtual worlds programming environment, also can be used to create interactive animated games and stories (Alice website, 2015). For instance in research (Rodger, Dalis, Gadwal, Hayes, Li, & Liang, 2012; Rodger et al., 2009), Alice programming was taught in K-12 teachers' workshop. Programming tutorial, template worlds and objects were provided to help teachers develop lesson plans. Many science teachers and language art teachers applied Alice programming features to teach different science concepts in class interactively, or used Alice as a supplementary tool to facilitate teaching. The research result shows that many teachers expressed positive feedback on continuing using Alice in the future. Another study also described successful experiences when Alice programming were introduced to high schools teachers to improve their teaching (Cordova, Eaton, & Taylor, 2011). Additionally, StarLogo providing 3D graphics, sound and blocks-based interface is a great tool to easily create 3D games and simulations for understanding complex systems (StarLogo website, 2015). Ahern's study reported that three middle school teachers with no computer background were introduced to StarLogo (Ahern, 2009). They developed and integrated models into their core discipline and stimulated general discourse in classrooms. The results indicated that students were curious and highly-engaged in learning. As regards pre-service teachers' training, Fesakis and Serafeim mentioned the positive effects of Scratch programming on pre-service teachers' opinions and attitudes toward computer programming and information and communications

technology (ICT) educational value (Fesakis & Serafeim, 2009). Pre-service teachers' interest to use ICT as educational tools was increased; meanwhile, their stress and anxiety implementing ICT in educational practice was also decreased by familiarization with Scratch. This study proposed a better future using Scratch in the course of computer programming for teachers.

### **Game creation approach**

In consideration of pre-service teachers' learning motivation, game creation approach may be a possible teaching method. Previous research has shown that computer game creation increases learners' skills, confidence, and motivation with programming (Rajaravivarma, 2005; Salen, 2007; Al-Bow et al., 2009; Eow, Ali, Mahmud, & Baki, 2010; Basawapatna, Koh, & Repenning, 2010). A programming game is usually composed of different functionalities including graphics, sound, animation, inputs, output and interesting challenge mechanism. Creating a game requires the understanding of all aspects of programming process. In addition to basic programming concepts and program structures application, it also includes algorithm design and complex problem-solving process which are useful for the development of advanced independent thinking. Thus, it is believed that encouraging game development is an effective way to inspire programming learning motivation. It enables learners to participate in the output of knowledge actively rather than receiving it passively.

It is a new trend for teachers nowadays to apply programming as a teaching tool to design learning activities into their discipline. Including the research mentioned above (Bell, Frey, & Vasserman, 2014; Cordova, Eaton, & Taylor, 2011; Rodger et al., 2012), the training of teacher-related programming competence mainly focuses on in-service teachers. Pre-service teachers are usually equipped with little programming background knowledge because they do not specialize in computer science. To especially improve pre-service teachers' programming ability before they enroll in K-12 teacher profession, improvements in the cultivation of programming skills need to be considered more seriously. Therefore, this study aims to investigate programming concept teaching for pre-service teachers with game creation approach. Scratch, having interactive visual interface and media-rich programming environment that is suitable for novice programmers, was chosen as the programming language for pre-service teachers.

### **Research Method**

#### *Participants*

The study was conducted in the teacher education course of "Computers and Instruction," in the Spring 2014 aiming to improve students' ability to integrate technology for teaching. This course took two hours per week. Students enrolled in this course were pre-service teachers. Twenty-two pre-service teachers comprising 10 males and 12 females were involved in this study. They came from different majors including Chinese, English, History, Chemistry, Business, and Counselling. They almost had no prior experience in computer programming.

#### *Research Questions*

The aim of this study was to explore the effect of game creation approach on pre-service teachers' programming learning. For this purpose, questions presented below were answered:

1. Is game creation approach a feasible strategy for teaching programming concepts to pre-service teachers?
2. What are pre-service teachers' attitudes and experiences of programming learned in this study?

### *Procedures*

Pre-service teachers were introduced to basic programming concepts and knowledge through instructor's lectures. They exercised and took practices of Scratch game programming. Scratch 1.4 was used in this study. Take the following game program example used in the class. When bananas randomly falls down from above, one monkey will move horizontally to catch the bananas and score. The introduction of Scratch programming lasted for 6 weeks. In the first week, pre-service teachers were informed that they had to design a game project for the use of teaching related to their future teaching discipline after learning fundamental programming concepts. The pre-service teachers chose their own groupings for designing their project. They can choose to finish the project alone or cooperatively with another partner. Finally, pre-service teachers were required to finish the project and share it with peers in class in the tenth week. One questionnaire designed by the author was used to collect information on pre-service teachers' attitudes and experiences of programming learned in this study.

### *Data analysis of participants' projects*

The content of pre-service teachers' projects was further analyzed to examine whether programming concepts were applied in project implementation. According to the characteristic of programming concepts, the program codes of each project were examined to count the frequency of the 6 categories applied in the project: variables assignments, logic and arithmetical operators, if statements, loop statements, subprogram definitions (when I receive <message> in Scratch) and thread (parallel execution).

## **Results and Discussion**

### *Participants' response to the Questionnaire*

Pre-service teachers' response to the questionnaire was summarized from the following perspectives: attitudes toward learning programming, responses of programming improvement and attitudes toward game project implementation. The results are discussed as below.

### *Attitudes toward learning programming*

Table 1 shows pre-service teachers' attitudes toward programming learning. The result reveals that most pre-service teachers had positive experiences while

learning programming. Nearly all pre-service teachers thought learning programming is important (Question 1) and it can enhance their capacity of logical thinking (Question 2). Eighty-five percent of pre-service teachers also agreed that non-majors like them can learn programming well (Question 3). Meanwhile, they also thought that it is not difficult to facilitate teaching by programming (Question 4). This questionnaire also gives participants chances to express their thoughts and feelings about Scratch programming. It is found that most participants favored learning programming with Scratch. They all agreed that Scratch is a proper language for novice programming learners (Question 5). As to the teaching method, 95% of pre-service teachers agreed that learning programming by game creation approach is feasible (Question 6). Pre-service teachers have high intention to create learning content by Scratch in the future (In Question 7, strongly agree and agree: 95%).

Table 1: Pre-service teachers' attitudes toward programming learning (N=22).

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1. Learning programming is important.	32%	64%	4%	0%	0%	4.27
2. Learning programming can enhance the capability of logical thinking.	45%	50%	5%	0%	0%	4.41
3. Non-majors like me can learn programming well.	36%	59%	5%	0%	0%	4.32
4. It is not difficult to facilitate teaching by programming.	27%	59%	14%	0%	0%	4.14
5. Overall, Scratch is a proper language for novice programming learners.	23%	77%	0%	0%	0%	4.23
6. Learning programming by game creation approach is feasible.	45%	50%	5%	0%	0%	4.41
7. I would like to create learning content in future by Scratch.	27%	68%	5%	0%	0%	4.23

### *Responses to programming improvement*

With respect to pre-service teachers' responses to programming improvement, the results are summarized in Table 2. A majority of pre-service teachers felt that they have learned many fundamental program concepts (Question 1). All pre-service teachers agreed that they can better understand the complete concept of program development process and steps (Question 2), and their programming development ability has been enhanced (Question 3). Eighty-seven percent of pre-service teachers also indicated that they were more familiar with program debugging methods and strategies (Question 4). Being asked about their programming learning intention, most of them would like to receive programming challenges (Question 5). After learning Scratch, their programming confidence had been promoted (Question 6). Overall, 82% of pre-service teachers were satisfied with their programming skill after learning Scratch (Question 7).

Table 2: Pre-service teachers' responses to programming improvement (N=22).

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1. I have learned many fundamental program concepts.	36%	55%	9%	0%	0%	4.27
2. I can better understand the complete concept of program development process and steps.	32%	68%	0%	0%	0%	4.32
3. My programming development ability has been improved.	36%	64%	0%	0%	0%	4.36
4. I am more familiar with program debugging method and strategies.	32%	55%	13%	0%	0%	4.18
5. I would like to receive programming challenges.	27%	68%	5%	0%	0%	4.23
6. My programming confidence has been improved.	32%	59%	9%	0%	0%	4.23
7. I am satisfied with my programming skill at present.	32%	50%	18%	0%	0%	4.14

### *Attitudes toward game project implementation*

Questions in Table 3 gathered pre-service teachers' impressions on game project implementation. All pre-service teachers agreed that using game programs to assist teaching can promote students' learning motivation (Question 1). Game project implementation provides opportunities to combine theory with practical application. Eight-six percent of pre-service teachers felt that they can apply related education theory when designing and implementing game project (Question 2). It is also found that 86% of pre-service teachers have intentions to design programming game projects to assist teaching (Question 3). Finally, question 4 examined pre-service teachers' intention to apply programming as a teaching tool. Positive feedback has been received, indicating that 86% of pre-service teachers strongly agreed or agreed on this investigation. From these positive responses, it can be concluded that game project design encouraged pre-service teachers to practice on what they have learned before. Not only programming skill but also education theory can be practically applied in this learning by practicing programming skills. These positive experiences increase pre-service teachers' intention to use programming to assist teaching activities in future.

Table 3: Pre-service teachers' attitudes toward game project implementation (N=22).

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
1. Using game programs to assist teaching can promote students' learning motivation.	50%	50%	0%	0%	0%	4.50
2. I can apply related education theory to game project design and implementation.	41%	45%	14%	0%	0%	4.27

3.	I would like to design programming game project to assist teaching.	23%	63%	14%	0%	0%	4.09
4.	In future, it is possible for me to apply programming as a teaching tool.	23%	63%	14%	0%	0%	4.09

### *Analysis of projects code implementation*

Pre-service teachers proceeded with their game design by choosing to work in partners or alone and by choosing the content of their project. Ten pre-service teachers designed their projects alone, while other 12 pre-service teachers liked to do projects cooperatively with another partner. Thus, a total of 16 projects was finished after the study. The subjects of these projects include Chinese learning, English learning, History, Chemistry, Business and Counselling. The analysis results of the programming concepts contained in project code implementation are showed in Table 4. As indicated in Table 4, each category of programming concepts was found in the projects code implementation. It reveals that pre-service teachers applied many different important programming concepts to their project design. The category of “subprogram definitions” was applied most often (34%), whereas the second most frequent category was “thread” (22%). The other programming concepts which are related to program flow control, such as “if statements” and “loop statements”, were also used often in projects. Moreover, “loop statements” were further examined to see whether different loop concepts were utilized in the projects. The results depicted in Table 5 provide evidence that pre-service teachers can execute different loop codes to have nonlinear narrative structures.

Table 4. Categorical accounts of the programming concepts in participants’ projects.

	Variables assignments	Logic and arithmetical operators	If statements	Loop statements	Subprogram definitions	Thread	Total
Count	391	360	256	284	1033	657	2981
Percentage	13%	12%	9%	10%	34%	22%	100%

Table 5. Categorical accounts of different loop statements in participants’ projects.

	For loop	While loop	Repeat until loop	Total
Count	196	67	21	284
Percentage	69%	24%	7%	100%

### **Conclusion**

Although prior research on using game creation approaches to engage students on programming learning has been conducted, little has been done to apply this strategy to the learning of pre-service teachers’. This study aimed to explore whether game creation approach is a feasible strategy for teaching programming concepts to pre-service teachers with no prior programming experiences. Twenty-two pre-service teachers enrolled in teacher education course of

“Computer and Instruction” were involved in this study. The findings indicated that pre-service teachers’ programming concepts and design skills have been improved after this study. Furthermore, most pre-service teachers had positive attitudes toward learning programming with game creation approaches. They were satisfied with their programming achievement. Game project design encouraged them to practice on what they have learned before.

In terms of qualitative analysis of participants’ project code implementation, it suggests that most project codes included many different fundamental programming concepts. In summary, this study demonstrated a feasible approach for the effective instruction of programming concepts to pre-service teachers with no prior programming experiences. Research results shows that pre-service teachers can learn programming concepts and apply them in their project code implementation. Their programming confidence had been promoted. They also had high intention to apply programming to assist their teaching in future.

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