A STUDY ON THE ADOPTION OF SCRATCH BY PRE-SERVICE INFORMATION TECHNOLOGY TEACHERS

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ABSTRACT
Several technology integration projects have been implemented throughout the world to promote effective use of information and communications technologies in public schools. Through these projects, interactive smart boards for each classroom and tablet computers for each student and teacher have been provided. Information technology teachers can ensure effective use of these technologies in education by focusing on curriculum integration strategies such as employing software programs and interactive learning environments. Scratch is a visual programming environment that allows users to create interactive games, animated stories, and simulations. Acceptance and use of this educational programming language is advantageous as it provides a collaborative learning environment in which students work together on a project and develop their creative thinking and problem-solving skills. Moreover, it enriches the curriculum and expands use of tablet computers and interactive smart boards in education. The purpose of this study is to identify factors affecting pre-service information technology teachers’ intention to use Scratch. A structural equation modeling approach was used to test proposed hypotheses and research model based on the Technology Acceptance Model. The research model, which explains 79% of the variance in intention to use Scratch, has a strong predictive power. The findings have important implications for teachers, principals, and policy makers.

KEYWORDS
Scratch, Programming, Technology Acceptance Model
INTRODUCTION

Scratch is an educational software developed for teaching computer programming to novice students. However, Scratch does not support the learning of programming through writing long codes using complex structures and following rigid syntax rules which are familiar to expert programmers (Ford, 2008). Rather, it motivates beginners to be involved in programming by raising their interest in interactive games, animated stories, and simulations (Kordaki, 2012).

Compared to classic programming languages, Scratch has numerous advantages, such as providing immediate feedback, motivation, visualization, and interactivity; developing problem-solving skills; emphasizing the design of the algorithmic solution rather than memorizing the syntactic rules; providing a rich set of usable coding tools; encouraging active, multi-sensory, and experimental learning (Resnick et al., 2009; Kordaki, 2012).

Since students do not have to write codes following rigid syntactical rules, programming is more meaningful and playful within Scratch. Students insert command blocks which form scripts that control the interactive interface. Moreover, Scratch 2.0 has a new camera programming block that allows students to create projects that react to movements in the physical world (Carini, 2012). Recently, Lin and Chang (2015) developed a body motion interactive game on Scratch 2.0 to motivate students with disabilities to perform physical activities. The experimental results indicated that the scores significantly increased during the intervention phrases.

Scratch ease programming for every one of all ages, backgrounds, and interests (Resnick et al., 2009). For example, Ferrer-Mico, Prats-Fernández, and Redo-Sánchez (2012) investigated how Scratch impacts self-directed learning capability in mathematics curriculum. Their results indicated that Scratch programming help students improve understanding of their own learning process. In another study, Theodorou and Kordaki designed a collaborative game using Scratch for high school students to teach variables in programming. Their results suggested that the students can conceptualize different aspects of variables in programming by playing and interacting each other.

Recently, several technology integration projects have been implemented in different countries: Preparing Tomorrow’s Teachers to Use Technology (PT3) in the US, Smart Education in South Korea, and Movement of Enhancing Opportunities and Improving Technology (FATIH) in Turkey. The success of these large-scale projects heavily depends on successful curriculum integration strategies. A successful integration can be ensured by employing strategies such as using software programs that works seamlessly on tablet computers and smart boards by allowing students to create, manipulate, and produce, designing problem-based assignments, and creating constructivist learning environments (Johnson, Maddux, & Liu, 2000). Scratch provides an interactive learning environment, which enables effective use of smart boards and tablets in education. It also provides a collaborative learning environment in which students work together on a project and develop their creative thinking and problem-solving skills. Thus, acceptance of this educational programming language by information technology teachers is a significant research area that needs investigation. However, in the literature, no study investigating pre-service information
technology teachers’ attitudes and intentions toward using Scratch is reported. Therefore, the latter point is the main motivation behind the current study.

The paper is arranged as follows: the next section presents the theoretical background of the study and hypotheses. Then, the research method, data analysis, and results are presented. Lastly, the discussion of the research findings and implications for researchers and practitioners along with the limitations of the study are provided.

THEORETICAL BACKGROUND AND HYPOTHESES

This study used the Technology Acceptance Model (TAM) (Davis, 1989) as an initial theoretical framework to investigate key factors affecting attitudes and intentions toward using Scratch. TAM suggests that two theoretical constructs, perceived usefulness and perceived ease of use are significant factors in explaining the variance in users’ intentions to use a system. These factors are fundamental determinants of system use and can be widely applied to solve the acceptance problem (Taylor & Todd, 1995).

Perceived usefulness

Perceived usefulness is defined as “the degree to which a person believes that using a particular system will enhance his or her job performance” (Davis, 1989, p. 320). This variable is related to some other constructs, including relative advantage (Innovation Diffusion Theory, IDT), performance expectancy (Unified Theory of Acceptance and Use of Technology, UTAUT), extrinsic motivation (Motivational Model), job-fit (Model of PC Utilization), and outcome expectations (Social Cognitive Theory) (Venkatesh, Morris, Davis, & Davis, 2003). Scratch provides a social and constructivist learning environment in which several activities can be performed. Information technology teachers can apply these activities in teaching programming to novice students. For example, interactive games and arts which enhance the students’ motivation and creativity can be developed by using Scratch. The students can also be asked to solve a given problem on Scratch while interacting and collaborating with classmates. It is therefore advantageous to use this software in education. On the basis of the above theoretical background and prior empirical validations, the following hypothesis is formulated:

H1: Perceived usefulness will have a positive influence on attitudes toward using Scratch.

Perceived ease of use

Perceived ease of use is defined as “the degree to which a person believes that using a particular system will be effortless” (Davis, 1989, p. 320). Innovations that are perceived by its potential users as having less complexity will be adopted more rapidly than other innovations (Rogers, 1995). Perceived ease of use (similar to complexity in IDT and effort expectancy in UTAUT) has been identified in prior studies as a significant predictor of adoption behavior. Rogers (1995) found that perceived ease of use has also a significant effect on perceived usefulness. Scratch’s user interface has a selection area, a scripts area, a blocks palette, and a stage. Programming with Scratch is as simple as selecting characters in the selection area and dragging blocks to the scripts area, where they snap together if syntactically appropriate. Students can create their own interactive games, stories, animations, music, and art by using these blocks, which specify instructions to implement expressions, statements, loops, conditions, and variables. The easier it is to perform these tasks, the lower the level of complexity and the easier and quicker perception of the advantages provided by Scratch. Deriving from the above theoretical and empirical support, the following hypothesis is formulated:

H2: Perceived ease of use will have a positive influence on perceived usefulness.

H3: Perceived ease of use will have a positive influence on attitudes toward using Scratch.

Attitude

Attitude can be defined as the degree of pre-service information technology teachers’ favorable or positive feeling about using Scratch. Likewise, behavioral intention can be defined as the degree of pre-service information technology teachers’ belief that they will use Scratch when they became teac-
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TAM suggests that behavioral intentions are determined by attitudes toward using a system. This implies that the more favorable the pre-service information technology teachers’ attitudes toward using Scratch, the greater will be their intention to use Scratch. Therefore:

H4. Attitude toward using Scratch will have a significant positive influence on behavioral intentions to use Scratch.

METHOD

Survey procedure and sample

In total, 100 pre-service information technology teachers completed an online survey. The participants’ ages ranged from 17 to 32 years. Majority of them (n= 94) were categorized in the 18-23 years age category. Mean age was 20.84 (SD= 2.36). Moreover, 56% of the respondents were female, while 44% were male.

Instrument

A scale developed by Davis (1989) to measure two theoretical constructs, perceived usefulness and perceived ease of use was used in this study. Davis (1989) developed his psychometric scale in three stages; a pretesting phase with a sample of 15 computer users, an empirical field study with a sample of 120 computer users, and a laboratory experiment with a sample of 40 voluntary MBA students, each time the scale was modified and refined. In addition, the items measuring attitude and behavioral intention were adapted from the Theory of Planned Behavior (Fishbein & Ajzen, 1975; Ajzen, 1991). The instrument has total 20 Likert items, including 6 items for perceived usefulness, 6 items for perceived ease of use, 4 items for attitude, and 4 items for behavioral intention. Participants were asked to indicate their level of agreement using a five-point scale ranging from “strongly disagree” to “strongly agree”. The measurement items were shown in the Appendix.

DATA ANALYSIS

Validity and reliability

Construct validity and internal consistency were assessed by reliability, convergent and discriminant validity. Reliability analysis results indicated that the instrument has a strong internal consistency with the Cronbach’s alpha values ranged from .91 to .93 (Creswell, 2005).

Convergent validity is judged to be adequate when average variance extracted (AVE) exceeds .50 (Hair, Black, Babin, & Anderson, 2010), construct reliability (CR) exceeds .70, and CR > AVE. In Table 1, the AVE values for all variables exceed .50, the CR values exceed .70, and all CR values higher than the AVE values, indicating that the convergent validity was satisfactory for all constructs.

Discriminant validity is judged to be adequate when AVE > MSV (maximum shared squared variance) and AVE > ASV (average shared squared variance). In Table 1, the ASV values for each variable are lower than the AVE values. However, the MSV values for attitude and behavioral intention are slightly higher than the AVE values. These results suggest that the discriminant validity for the variables of the measurement model was adequate.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cronbach's Alpha</th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>ASV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Ease of Use</td>
<td>.93</td>
<td>.94</td>
<td>.71</td>
<td>.50</td>
<td>.44</td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>.93</td>
<td>.94</td>
<td>.72</td>
<td>.60</td>
<td>.53</td>
</tr>
<tr>
<td>Attitude</td>
<td>.93</td>
<td>.93</td>
<td>.77</td>
<td>.79</td>
<td>.63</td>
</tr>
<tr>
<td>Behavioral Intention</td>
<td>.91</td>
<td>.92</td>
<td>.73</td>
<td>.79</td>
<td>.59</td>
</tr>
</tbody>
</table>

Table 1. Reliability, Convergent and Discriminant Validity
**Measurement models**

A structural equation modelling (SEM) approach was employed via maximum likelihood using SPSS AMOS (v.22; IBM Corp. Released 2013. IBM SPSS AMOS, Armonk, NY, USA) to test the research model. The model produced acceptable fit indices. Results of the confirmatory factor analysis demonstrated that all of the scales used in this study formed adequate measurement models, and thus, provided evidences for the construct validity of the measures. The goodness of fit indices for the model were: \( \chi^2/df = 2.35, \) GFI = .74, AGFI = .66, NNFI = .88, NFI = .84, CFI = .90, IFI = .90, RMSEA = .077. The value of Chi-square/df was 2.36, a ratio of less than 3 is considered to be appropriate (Kline, 2005). It is important to note that GFI and AGFI are sensitive to sample size, and therefore, GFI and AGFI scores were somewhat lower. NFI is also sensitive to sample size such that it underestimates fits for samples less than 200 (Kline, 2005).

**Structural models**

The SEM analysis was employed to test hypothesized relationships. Consistent with the hypotheses, the results indicated that all proposed paths among the latent variables are statistically significant. Figure 1 provides results of the SEM analysis, including the path coefficients with significance levels.

![Figure 1: Casual model of the students' intention to use Scratch](image-url)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Equation</th>
<th>Error</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness</td>
<td>(.68 \times \text{Perceived Ease of Use})</td>
<td>.24</td>
<td>.46</td>
</tr>
<tr>
<td>Attitude</td>
<td>(.75 \times \text{Perceived Usefulness} + .18 \times \text{Perceived Ease of Use})</td>
<td>.12</td>
<td>.79</td>
</tr>
<tr>
<td>Behavioral Intention</td>
<td>(.89 \times \text{Attitude})</td>
<td>.11</td>
<td>.79</td>
</tr>
</tbody>
</table>

Table 2: Structural equations for each variable
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Structural equations for each variable were given in Table 2.

**Hypothesis testing**

Summary of the hypotheses testing were listed below:

H1. Perceived usefulness will have a positive influence on attitudes toward using Scratch at the .001 level ($\beta=.75$; $t=6.23$; $p < .001$).

H2. Perceived ease of use will have a positive influence on perceived usefulness at the .001 level ($\beta=.68$; $t=6.37$; $p < .001$).

H3. Perceived ease of use will have a positive influence on attitudes toward using Scratch at the .05 level ($\beta=.18$; $t=2.09$; $p < .05$).

H4. Attitude toward using Scratch will have a significant positive influence on behavioral intentions to use Scratch at the .001 level ($\beta=.89$; $t=9.16$; $p < .001$).

**DISCUSSION AND CONCLUSIONS**

This study aims to investigate key adoption factors for an educational programming language called Scratch by pre-service information technology teachers. Recently, several large-scale technology integration projects have been implemented throughout the world. However, the success of these projects depend on curriculum integration strategies such as employing software programs that works seamlessly on tablet computers and smart boards. Scratch allows students to design and develop interactive games, animated stories, and simulations in a constructivist learning environment. Thereby, students work together on a project and develop creative thinking skills. Therefore, acceptance of such programs by pre-service information technology teachers is advantageous.

As teachers can decide whether to accept or reject a new technology or software program in schools, opinions from pre-service information technology teachers were elicited for this study. A research model based on TAM was developed to investigate factors affecting attitudes and intentions toward using Scratch. TAM suggests that two theoretical constructs, perceived usefulness and perceived ease of use are significant factors in explaining the variance in users’ intentions to use a system.

A SEM analysis using SPSS AMOS (v.22) was employed to test the hypothesized relationships, identify relationships among the constructs, and perform a confirmatory factor analysis to test the fit of the data to the measurement model. The min Cronbach’s alpha value was .91, which indicates a high level of internal consistency. Moreover, convergent validity and discriminant validity for the proposed constructs of the measurement model were adequate. The results suggested that the proposed model indicates a reasonable fit to the survey data with the following fit indices $\chi^2/DF = 2.35$, IFI = .90, TLI = .88, and CFI = .90.

Consistent with the hypotheses, results suggested that perceived usefulness and perceived ease of use have significant effects on attitudes. The results also demonstrated that attitude toward using Scratch has a significant positive influence on behavioral intentions. The proportion of total variance explained by the research model was 79%. The high proportion of the total variance explained indicates that the model includes a significant portion of factors that might affect behavioral intentions.

The fact that perceived usefulness has a significant effect on attitude toward using Scratch, suggests that the pre-service information technology teachers believe that Scratch would be a useful tool to do their job and using Scratch would enable them to use smart boards more effectively. Furthermore, they think that using Scratch would increase their productivity, enhance their effectiveness, improve their job performance, and ease their job. The results also indicated that perceived ease of use has a significant effect on attitude toward using Scratch. This suggests that the pre-service information technology teachers find it easy to become skillful at using Scratch and they believe that their interaction with Scratch would be clear and understandable.

These findings have several practical implications for teachers, principals, and policy makers. First, Scratch provides students a meaningful and playful...
learning environment to create interactive games, animated stories, and simulations. This implies that teachers should use appropriate instructional methods such as setting problem-based assignments in which students work together by enhancing problem solving skills. It is important to note that the schools with greater management support would be more likely to adopt such software programs. Therefore, principals should support use of Scratch among teachers not only for teaching computer programming but also for teaching math, physics or arts. Finally, governments may more strongly justify promotion of these programs among teachers at large. Thus, policy makers should provide policy guidelines on the use of such software programs in schools and update the related curriculum.

This study has a number of limitations. Since the data was collected from students studying computer education and instructional technology, the findings should be applied to subjects from other disciplines with caution. Moreover, it may be useful to employ a mixed method approach that incorporates both qualitative and quantitative methods for a deeper investigation of factors affecting attitudes and intentions toward using Scratch.
REFERENCES


APPENDIX: MEASUREMENT ITEMS

Perceived Usefulness
Using Scratch in my job would enable me to accomplish tasks more quickly.
Using Scratch would improve my job performance.
Using Scratch in my job would increase my productivity.
Using Scratch would enhance my effectiveness on the job.
Using Scratch would make it easier to do my job.
I would find Scratch useful in my job.

Perceived Ease of Use
Learning to operate Scratch would be easy for me.
I would find it easy to get Scratch to do what I want it to do.
My interaction with Scratch would be clear and understandable.
I would find Scratch to be flexible to interact with.
It would be easy for me to become skillful at using Scratch.
I would find Scratch easy to use.

Attitude
Using Scratch to teach programming is a good idea.
Using Scratch to teach programming makes my lectures more interesting.
Using Scratch to teach programming is fun.
Using Scratch on smart boards to teach programming is pleasant.

Behavioral intention
I intend to use Scratch to teach programming when I became a teacher.
I predict that I would use smart boards more effectively with Scratch.
I plan to use Scratch to teach programming in the future.
I intend to use Scratch on smart boards while teaching programming.