Motivating Programming Learners through Game Development

Genta Togashi
University of Hawai'i at Mānoa
genta@hawaii.edu
https://codefox.dreamhosters.com

Abstract: This study aims to promote learners' motivation for computer programming through game development. Motivation toward computer programming is key to academic success for prospective Computer Science (CS) students. Students will learn effectively if they are motivated, and they will be able to maintain their motivation if they have the confidence to achieve their goals (Jenkins, 2001). Game development is an ideal programming topic for motivating new programming learners. The purpose of this instructional design project was to design and evaluate a game development-based module to provide a motivational introductory programming experience for undergraduate students at the University of Hawai'i at Mānoa. A coding module platform to support live editing and a preview of a JavaScript 2D-game was developed using Wordpress, Phaser, and Ace. A series of instructional screencasts was integrated into the coding module platform. John Keller's Attention, Relevance, Confidence, Satisfaction (ARCS) model was used for the design of the instructional module and survey instruments. An online module evaluation was conducted with 19 participants, and survey and module usage data were collected. The results indicated overall increases in motivation and confidence levels and the positive impacts of using the module. The record also implied a potential link between the increase in learners' knowledge and their confidence levels after working on the module. These results guided the research for further improvement of the instructional module.

Statement of the Problem

There are high demands for more students in CS from higher education institutions. The U.S. Bureau of Labor Statistics projected a 13% increase in employment of computer and information technology occupations from 2013 to 2026 ("Computer and Information Technology Occupations," 2018). Based on the analysis of Code.org, 58% of new Science, Technology, Engineering, and Mathematics (STEM) jobs are in computing, and only 8% of STEM graduates are in CS ("Computer Science Education Stats," n.d.). As the use of information technology becomes indispensable today, the projected shortage of new information technology professionals will be a serious issue. Thus, recruiting and retaining CS major students in higher education institutions is critical.

One of the major barriers to the CS program for undergraduate students is the development of computer programming skills. According to an academic advisor in the CS department at the University of Hawai'i at Mānoa, many students come to the

discipline with interests in computer technologies such as video gaming, yet they have a difficult time building basic competency in programming. Learning programming requires patience, and a fair amount of continuous practices are required for developing programming skills. However, many first-year students feel overwhelmed by programming concepts and fail to keep up with their coursework. As a result, some of them withdraw from the CS program.

One way to remediate the situation is to promote learners' motivation for computer programming through game development. Game development is an ideal programming topic for motivating new learners in the field. Many studies have reported the positive impacts of game developments (Dickson, 2015; Leutenegger & Edgington, 2007; Sung et al., 2011; Wang & Wu, 2015). Students will learn effectively if they are motivated, and they will be able to maintain their motivation if they have the confidence to achieve their goals (Jenkins, 2001). A self-directed instructional module with game development will motivate undergraduate students to study CS and prepare them for programming as they will be able to gain hands-on experience in computer programing prior to entering the field.

There are many self-programming practice websites, such as Codecademy, on the Internet. Yet, many of them are aimed at the mastery of specific functions of programming languages and not well suited for first time programming learners who have no knowledge of coding concepts in terms of the scope and presentation of the content. In order to better prepare students for the discipline, an instructional module that focuses on learners' affective domain is needed.

The purpose of this instructional design project was to design and evaluate a game development-based instructional module to provide a motivational introductory programming experience for undergraduate students at the University of Hawai‘i at Mānoa. The instructional module developed in this project will be available online to anyone who is interested in programming.

Literature Review

Game Programming in CS. CS has a unique relationship with video games as the discipline provides a foundation to game development, i.e., algorithm, data structure, software engineering, and human-computer interaction (Johnson et al., 2016). Thus, many studies have investigated ways to integrate game development in the CS curriculum. For instance, Leutenegger and Edgington (2007) described how they used game development in the first-year CS core curriculums and received favorable feedback from the students enrolled. In particular, they noted the positive impact on the female population. Moreover, Dickson (2015) compared several development platforms, including Xcode, Bali, and Unity, and discussed the positives and negatives. He conveyed the significance of choosing a platform with a shallow learning curb so that students can focus on the development instead of spending too much time with learning tools. Further, Wang and Wu (2015) presented a literature survey to determine how game development is used in the CS curriculum with topics and development frameworks.

These studies, which include practical examples, provide insight into designing an instruction module based on game development.

Game-Based/Game Development-Based Learning. Literature on game-based learning (GBL) and game development-based learning (GDBL) has provided theoretical frameworks for this study and has shown that integrating games into instructions impacts learners' motivations. Prenskly (2003) described how contemporary learners differ from previous generations and how computer games may create a new learning culture. Additionally, Kiili (2005) suggested using games to gain students' attention to create new learning situations that engage learners. As Kiili (2005) pointed out, the use of technology alone does not motivate students whose entire lives have involved computers and technologies. Wu and Wang (2012) described the common practice of integrating game development into programming as GDBL and discussed its pedagogical context. They explained that GDBL supports constructing learners' new knowledge by providing the experience of creating games and using software that is personally meaningful to young learners. They also pointed out that activities based on GDBL can be considered as applying Dowey's (1992, 1997) "learning by doing" instructional strategy; therefore, GDBL can engage learners and support learning.

ARCS Model. John Keller developed the ARCS model as an instructional strategy to promote learner's motivations. It consists of four components: attention, relevance, confidence, and satisfaction. Several researchers show successful applications of the ARCS model in computer programming education. Alhazbi (2015) emphasized the importance of motivating students to improve their learning process for programming skills and applied the model to computer programming courses. He was able to implement the ARCS model and observed its positive impacts in a computer programming context. Tukamoto et al. (2013) also applied the ARCS model to enhance teaching materials for programming education. They used questionnaires based on the ARCS model to identify problematic sections of teaching materials and were successfully able to improve learners' engagement in programming education courses.

Methodology

Research Questions/Goals. This project addresses two research questions: How does the game development-based instructional module promote learners' motivation? How does the game development-based instructional model contribute to building learners' confidence in their programming skills? Results obtained in this study will be used for further improvements to the instructional module.

Content Analysis. The JavaScript programming language was chosen since it is considered as a standard programming language for the World Wide Web and is recognized as the most widely adopted computer language ("JavaScript Trends in 2018," 2018). While some basic programming concepts are introduced, such as commands, sequencing, looping, conditionals, and functions, the primary focus of this instructional module is to improve learners' motivation and confidence in programming. Therefore, the domain of learning of this instructional module is the affective domain. Novice

learners often consider programming as a complex and difficult subject. Development of the affective domain will enhance learners' ability to gain knowledge on their own and will help them achieve their academic goals.

The first approach of the module content design involved incorporating traditional "Hello World" type programming exercises, i.e., writing code to present simple words on a screen or creating a simple program to simulate a banking machine. However, based on peer feedback, it was realized that the content has to be updated so that it engaged learners. The second approach involved providing instruction through gameplay. Specifically, learners controlled a game character in a maze using programming commands. However, this game-based approach tends to make coding too simple, and it was not appropriate for college students.

After performing an additional review of programming education literature, GDBL was chosen as a core component of this project. Learners were expected to develop a simple 2D platform game by writing code. Developing a simple 2D platform game provides enough complexity as a coding exercise and provides a "sense of control" since learners are able to modify various configurations of the game and can control the game world. It introduces the power of coding to new programming learners.

The development of the 2D platform game was divided into six steps so that learners were gradually able to complete new programming tasks. Appendix A shows the basic organization of the module. Each step focused on adding game assets such as a background, platforms, and a player character. Programming concepts were introduced as needed.

Recruitment and Participants. The target audience of this project were undergraduate students who were interested in learning computer programming or were going to enroll in the CS program. Participants for this study needed to be 18-years-old or older with basic technology literacy skills, including keyboarding, emailing, and web browsing skills. They also needed to be able to process online instructional modules by themselves. Further, participants need to have access to computers with the Chrome web browser and high-speed Internet. The researcher intentionally excluded current CS students from the recruitment since this module was targeting prospective CS students without a CS background.

In order to recruit participates who met the target population requirements, a recruitment message (Appendix B) was sent to students who had completed or were currently enrolled in Learning Design and Technologies (LTEC) 112 "Technology for Academic Success." LTEC 112 is an online course that teaches undergraduate students certain academic technology skills. The recruitment message was sent to Fall 2018 and Spring 2019 students and included a brief summary of this study, the procedure, and the researcher's contact information. Starbucks gift certificates ($5 each) were offered to encourage students to participate in the study. However, only two students expressed interested in the study. In order to reach out to more participants, the researcher made modifications to the original recruitment procedure to include the LTEC student mailing

list as a recruitment source. The researcher also created a visually appealing recruitment flyer (Appendix C) to gain the attention of potential participants. The second recruitment message was sent to the LTEC student mailing list in the first week of February, and 24 people expressed interested in the study.

Table 1

Demographics and technology skills of participants

	Number	Percentage
Age Ranges		
21-29	2	10.53%
30-39	6	31.58%
40-49	9	47.37%
50-59	2	10.53%
Occupation		
Graduate student	11	57.89%
Alumni	5	26.32%
Faculty and staff	3	15.79%
Self-assessment of technology skills		
5 - Advanced	5	26.32%
4	7	36.84%
3 - Intermediate	5	26.32%
2	0	0.00%
1 - Novice	2	10.53%
Previous coding experience		
Yes	11	57.89%
No	8	42.11%

A total of 19 participants, 6 males and 13 females, have completed the study. Table 1 shows the basic demographics of the participants based on the module evaluation survey. The majority of participants were between 30 and 49 years of age, and they were mostly LTEC graduate students or alumni. The majority of the participants rated their technology skills from intermediate to advanced. Eleven participants had prior coding experience, and 8 were new to coding. Since the target audience of this project was undergraduate students, the age ranges of participants were higher than originally expected. The change in the recruitment method due to the low enrollment impacted this outcome. However, based on their technology background and diverse coding experience, the participants matched with the learner characteristics of the target audience.

Evaluation Instruments. In order to measure how the instructional module impacts learners' motivation, an attitudinal survey questionnaire was developed (Appendix F). The survey questionnaire consisted of two sections of background information and three sections on the module evaluation. The first section focused on participants' demographic information, including age, gender, and educational background. The second section required participants to share information about their technology background, such as their technology proficiency level and their prior experience with programming. This section also included questions regarding participants' experience with video games. The third section focused on an evaluation of the module, and 12 evaluation questions were developed based on the subcategory of the ARCS model to examine the instructional module's method of effectively motivating individuals to learn computer programming (Keller, 2000). The fourth section includes retrospective questions to compare learners' interest and confidence in computer programming before and after the instruction. The final section contained open-ended questions in which participants provided an overall rating of the module and qualitative feedback.

In addition to the survey questionnaire, usage data of the instructional module were collected. Usage data included the start time and end time of each lesson, the scores of each programming exercise, and programming codes that participants. Unique identification numbers were assigned to the survey and usage data so that the data were able to match in the analysis phase.

Project Design Strategies. The goal of this project was to develop a self-directed instructional module to motivate novice programming language learners. Learners created classic 2D-style games based on step-by-step video instructions. This module employed the "learning by doing" strategy (Dewey, 1922, 1997). Each lesson presented coding tasks, and learners were required to write code and preview their work as they completed tasks.

Figure 1 shows the main layout of a coding lesson. The left side of the module presents tasks, video instructions, and coding tips. 'Tasks' represent the programming exercises learners need to complete in each lesson, e.g., adding code so that a player character can jump with a cursor key press. Instructional videos include approximately 5-8 minutes of screencasts to show how to implement game components specified in each module. In the videos, all the coding requirements are described in step-by-step processes, so learners

should be able to complete tasks as long as they can follow video instructions and type exactly as they are instructed. “Tips and Hints” provides additional information and useful topics when learners would like to expand the code further. The right side of the module includes an embedded coding editor, where learners can write code. Ace was used to implement editing functions so that learners are able to write code in the module without requiring external software. This is especially helpful for novice coders since one of the barriers to programming is the difficult setup of the coding environment. Ace provides syntax highlighting and coding assistance. If syntactical errors are made (e.g., parentheses do not match), the editor highlights the mistake and informs the learner that it needs to be fixed.

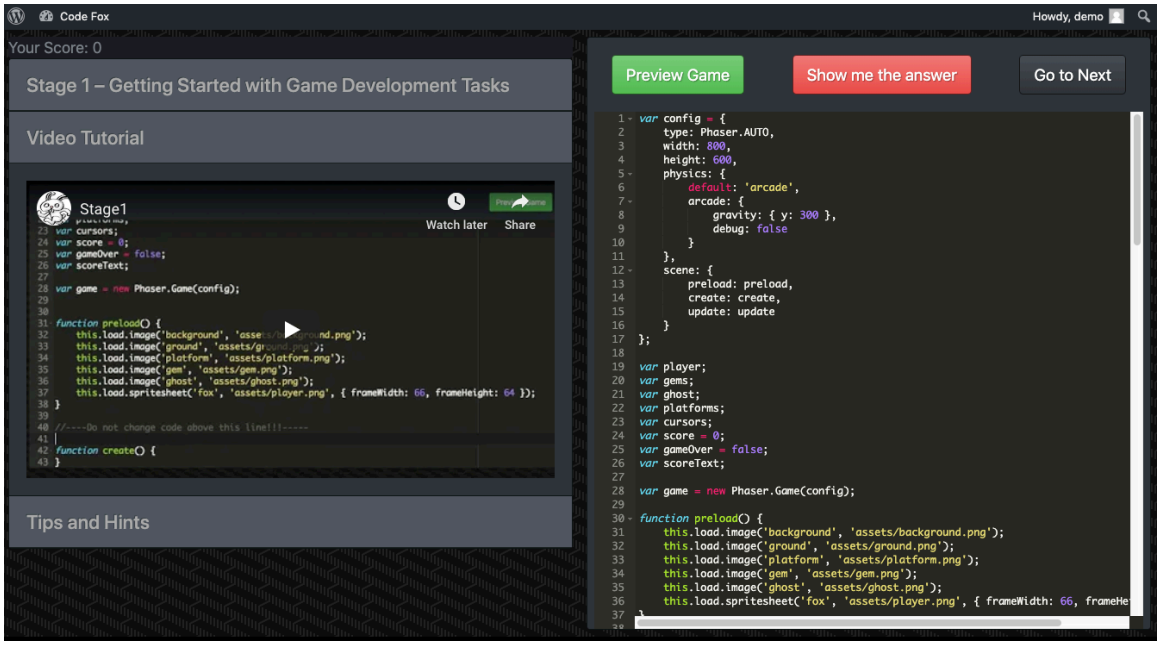

Figure 1: Main layout of the instructional module.

Once the coding is complete, learners can click “Preview Game,” which will open a new window to preview the game (Figure 2). In the preview window, learners can try the program they developed by using a keyboard. When learners are satisfied with the code, they can click “Submit & Go to Next” and move on to the next lesson. If learners are not able to find their coding errors, the “Show me the answer” button can be used. This button displays the correct code, and a learner is able to check the answer. However, the use of this button is discouraged by not giving a full score when it is used.

John Keller’s ARCS model was used for the motivational design, and the four components of the ARCS model, attention, relevance, confidence, and satisfaction, are used in the module design. For attention, the instruction uses the convention of a classic platform game, i.e., a character jumps around platforms and collect stars. The goal, rules, and structures from previous gaming experiences will be familiar to learners. For relevance, learners will have the opportunity to change the configuration of the game as they like. For instance, a player character can jump higher than the default configuration. For confidence, learners will solve a problem by writing code. By practicing

programming code and seeing changes in game visualization, learners will be able to gain confidence in coding. For satisfaction, learners will produce a playable game as the final product of these lessons, and this will lead to their satisfaction.

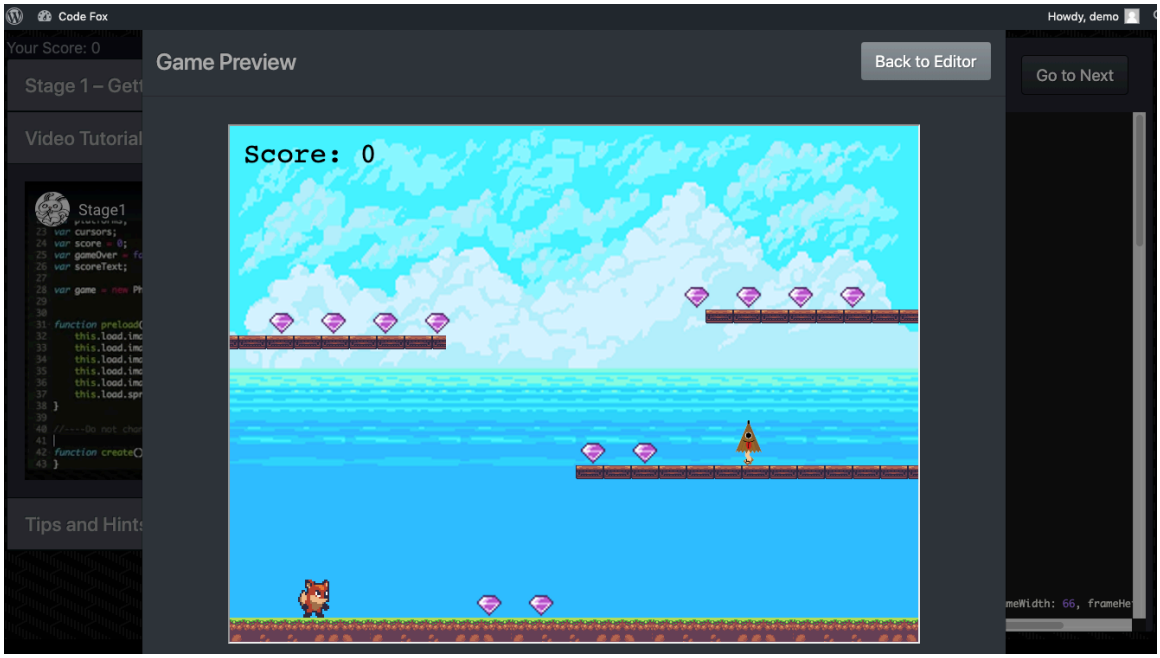

Figure 2. Game preview.

Procedures. The evaluation was conducted between January and February 2019 and involved the following steps: 1) an instruction to participate in the study (Appendix D) was sent via email to people who had expressed interest in doing so. The message contains informed consent and access information, including the website address of the modules and login credentials. The informed consent form stated that logging into the first page of the module implied the individual's consent to participate in this study. 2) Participants completed the online module, and the usage data were collected. 3) Upon completion of module trial, participants completed the survey questionnaire (Appendix E). 4) Follow-up emails (Appendix F) were sent to all participants to express the researcher's appreciation of their study participation.

The researcher was the primary contact person for this evaluation process. He sent the instructions and informed consent email to participants. Since this study involved the online evaluation of a self-directed instructional module, participants were able to process all activities on their own based on the instructions provided. However, participants contacted the researcher as needed if they had any issues, such as technical problems. There was only one evaluation session per participant, and each session required about 1-2 hours of commitment. All of the data, including the usage data of the module and survey questionnaires, were collected online.

The instructional module and the survey used a coded system in which the username of the module is a unique participant ID, e.g., P0001. The researcher kept a database of the participant IDs and participants' personal information, including their names and emails.

This information was only used for communicating with participants, i.e., troubleshooting or sending follow-up emails. The database file will be kept in an encrypted password protected computer. The researcher completed necessary training for the research protocol including proper handling of personal information prior to conducting the study (Appendix G).

Results

During the module evaluation, the module usage data were collected to observe the general usage and difficulty levels of the module contents. Table 2 shows a summary of the module usage at each stage. The average session time was calculated based on the timestamp information collected and shows how long participants worked on a stage. The second column shows the number of participants who opted to use the "Answer" button. The third column shows the percentage of participants who completed each stage. The majority of participants completed the first two stages; however, the completion rate decreased to 68% in stages 3 and 4. Stage 5 had the worst completion rate. Participants did not spend much time on this stage compared to the prior three stages. Participants used the "Answer" button more frequently as the stage progressed.

Table 2

Module usage summary

Module Section	Average Session time	# of Participants used the "Answer" Button	Completion Rate
Stage 1	0:06:49	1	84.21%
Stage 2	0:11:40	2	94.74%
Stage 3	0:11:26	3	68.42%
Stage 4	0:11:16	5	68.42%
Stage 5	0:08:15	5	52.63%
Stage 6	0:11:45	3	73.68%

In order to determine if the module provided motivational instruction to learners, 12 questions based on the ARCS model were prepared to measure variables in four categories: attention, relevance, confidence, and satiation (Table 3). Each question was mapped with a subcategory of the ACRS model, and participants were asked to answer to these questions in 5-point Likert scale, where "1" meant "Strongly disagree" and "5" meant "Strongly Agree." The means of attention, relevance, confidence, and satisfaction were rated between 3.7 and 4.1, and they are an indication of motivational learning

experiences. However, the statement “Each lesson of this learning module had clear goals” was rated lower than the other questions.

Table 3

Module evaluation based on the ARCS model

ARCS Category	Questions	Mean
Attention		**GM = 4.11**
Capture Interest	The content of this instructional module was interesting.	4.37
Stimulate Inquiry	I felt I wanted to learn more programming topics while working on this learning module.	3.79
Maintain Attention	I was able to maintain my interest throughout this instructional module.	4.16
Relevance		**GM = 3.72**
Relate to Goals	Each lesson of this learning module had clear goals.	2.79
Match Interests	The content of this module matched with my interests.	4.11
Tie to Experiences	The content of this instructional module was familiar to me.	4.26
Confidence		**GM = 3.75**
Success Expectations	This module was able to assist in building a positive experience for success.	3.89
Success Opportunities	The lessons I have learned in this module will lead to my future success.	3.47
Personal Responsibility	I was able to learn programming based on my efforts and abilities.	3.89
Satisfaction		**GM = 3.95**
Intrinsic Satisfaction	I will be able to use what I have learned in this module in the future.	3.84
Rewarding Outcomes	This learning module provided reinforcement for my success.	3.89
Fair Treatment	My accomplishment was fairly treated.	4.11

Note. Values are the means of reported scores on a 5-point scale. GM=Grand mean.

In order to measure the effectiveness of this instructional module, retrospective questions were used. Participants were asked to rate the four criteria: motivation level related to learning about computer programming, interest in learning computer programming topics, confidence level related to computer programming, and knowledge of programming before and after working on the module with the 5-point scale. A paired

sample *t*-test was conducted to compare the mean values of report scores before and after using the module (Table 4). The results indicated increases in the mean values in all four categories. The paired *t*-test indicated the statistical significance of learners' confidence and knowledge levels ($p < .001$). However, the increases of motivation and interest levels were not statistically significant.

Table 4

Results of the retrospective survey

	Before		After				
	M	SD	M	SD	*t*-cal	df	*p*
Motivation	3.53	1.02	4.11	0.74	1.93	18	.068
Interest	3.68	1.06	4.26	0.73	2.07	18	.052
Confidence	2.63	1.30	3.37	1.01	2.93	18	.009
Knowledge	2.63	1.16	3.47	0.77	3.02	18	.007

Note. M=Mean. SD=Standard Deviation. Values are the means of reported scores on the 5-point scale before and after working on the module.

The retrospective survey also indicated potential links among changes in the reported scores. As Figure 3 shows, learners' motivation and interest have a positive correlation (r = 0.79). In addition, Figure 4 shows a strong positive linear relationship between learners' confidence and knowledge level (r = 0.93).

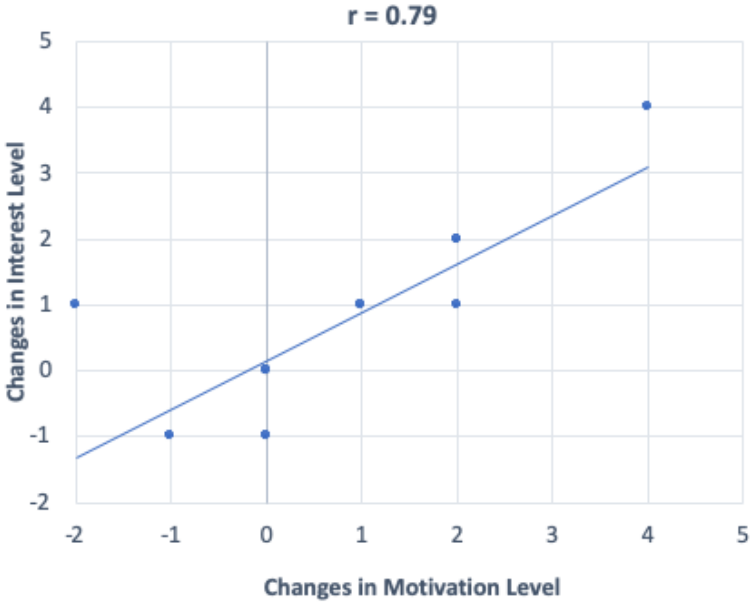

Figure 3: Changes in learners' motivation level vs. interest level.

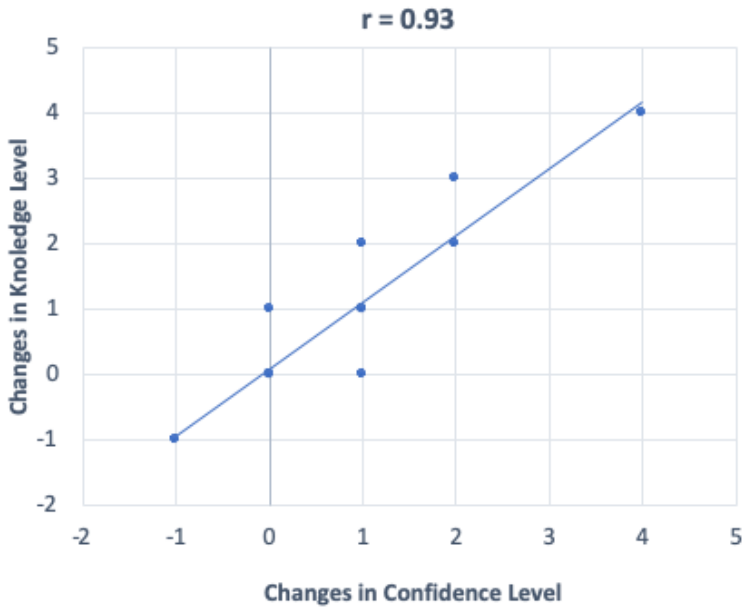

Figure 4: Changes in learners' confidence level vs. knowledge level

Discussion

The overall rating of this game development-based learning module was 4.37 on a 5-point scale on average, which indicated that this module was a positive learning experience for learners. In the qualitative feedback, a few participants commented that the game development was fun and engaging for them, and this perspective matched with other studies' findings (Leutenegger & Edgington, 2007; Wang & Wu, 2015). Participants liked the organization of the module and commented that the stages were divided into manageable sections. Participants also liked the built-in coding environment, which enabled syntax highlighting and an instant preview of the game. Based on these results, this instructional module will be a viable method to provide an initial coding experience.

Feedback on the module included some comments on the usability issues of the module. A few participants pointed out the inability to move to stages without restrictions. The module implemented a linear navigation structure so that the participants completed one stage and moved onto the next stage. However, participants sometimes needed to go back to previous stages to review videos and code on which they had worked. In addition, the module does not have the ability to save the working code. These issues made it difficult to go back to the previous module and return to the current work stage. Supporting the review workflow has to be addressed for further improvement of the module.

Other usability issues were related to the screencasts. While most users commented that the screencasts were clear and easy to follow, several users had a difficult time reading texts in the videos and had to use the full-screen mode. One of the features of this module is the ability to view a video and a coding editor at the same time so that users can type

the code explained in the video. Use of the full-screen mode will interrupt this workflow. More testing is needed to determine the best video resolution and video size. Some users reported that the video control hovered on the bottom of the code, which made it difficult to read the code. The video control can be removed by navigating a mouse away from the video, but it seems many users did not realize this. It appears that the lower completion rates from stage 3 onwards are related to this usability issue since some new code was added to the bottom of the video. It is necessary to improve these usability issues in the screencasts.

One of the research questions of this project concerned investigating was how the instructional module impacts learners' motivation. Evaluation based on the ARCS model indicated that the module consistently supported four motivation conditions. However, one question that asked whether each lesson of this learning module had clear goals was rated lower compared to other questions. A potential reason for this result is based on the way goals are described at each stage. Since this instructional module focuses on the development of the affective domain, the researcher avoided using of formal learning objectives. Instead, the outcomes of programming tasks were introduced at the beginning of each stage, e.g., moving a fox and creating gems. Since most participants were related to LTEC and were proficient in instructional design, they might have considered them as a lack of measurable performance objectives. Except this lower rating that the unique background of the participants potentially caused, the module was able to consistently support four motivational conditions.

While the retrospective survey indicated increases in learners' motivation and interest levels, the study was not able to show the statistical significance of the increases. One potential reason for this is that participants were already motivated and interested in programming. The mean score of the motivation level prior to trying the module was 3.57 on a 5-point scale. This might be an indication of the certain degree of the module's impact on learners' motivation during the recruitment phase. Most participants joined this study due to the flyer sent to the departmental mailing list (Appendix C), and it appears that the use of game development in coding instruction factored into the participants' motivation and interest. This matched with Kiili's (2005) recommendation to use games to gain the attention of learners and create learning situation. At the same time, this exposes the challenge of evaluating the module impacts on learners' motivation since games have instantaneous impacts on learners' motivation. Further studies are needed to find an optimal way to evaluate the module's impact on learners' motivation.

The second research question of this research investigated whether the module was able to increase learners' confidence level in coding. The retrospective survey was able to show that the module was able to increase learners' knowledge and confidence levels. The result also indicated a potential link between the change in learners' knowledge level and confidence level after working on the module. This implies the further enhancement of learners' confidence level in coding, as supporting learners' knowledge is essential. This instructional module was designed to focus on providing hands-on coding experience. Learners typed code as screencasts were presented, and a detailed explanation of each code was avoided so that they were not overwhelmed. Given that

students in higher education have high expectations related to developing their intellectual skills, learners wanted to know more about how the code they typed was working behind the scenes. One participant suggested including a more detailed explanation about what is happening. Maintaining an appropriate balance between contents for knowledge and hands-on coding exercises may be key for the further improvement of the module.

In conclusion, this game-development coding module is a viable means to provide an introductory coding experience, promote learners' motivation, and increase learners' confidence in coding. Programming is one of the most challenging curriculums in undergraduate CS education, and successful acquisition of the skills is key to the academic success of prospective CS students. Motivational coding experiences have a positive impact on their learning and help them achieve their academic goals. A game development-based instructional module can be an effective way to introduce individuals to computer programming, and it can contribute to an increased interest in CS.

References

Alhazbi, S. (2015). ARCS-based tacåtics to improve students' motivation in computer programming course. In *Computer Science & Education (ICCSE), 2015 10th International Conference on* (pp. 317–321). IEEE.

Computer and Information Technology Occupations: Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics. (2018, April 13). Retrieved October 6, 2018, from https://www.bls.gov/ooh/computer-and-information-technology/home.htm

Dewey, J. (1922). *Democracy and education: An introduction to the philosophy of education*. Macmillan Company, New York.

Dewey, J. (1997). *Experience and education*. Simon and Schuster.

Dickson, P. E. (2015). Using unity to teach game development: When you've never written a game. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 75–80). ACM.

JavaScript Trends in 2018. (2018, January 3). Retrieved October 14, 2018, from https://codeburst.io/javascript-trends-in-2018-3fb0077259

Jenkins, T. (2001). The motivation of students of programming. In *ACM SIGCSE Bulletin* (Vol. 33, pp. 53–56). ACM.

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development*, *10*(3), 2.

Keller, J. M. (2000). How to integrate learner motivation planning into lesson planning: The ARCS model approach. *VII Semanario, Santiago, Cuba*, 1–13.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, *8*(1), 13–24.

Leutenegger, S., & Edgington, J. (2007). A games first approach to teaching introductory programming. In *ACM SIGCSE Bulletin* (Vol. 39, pp. 115–118). ACM.

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE)*, *1*(1), 21–21.

Sung, K., Hillyard, C., Angotti, R. L., Panitz, M. W., Goldstein, D. S., & Nordlinger, J. (2011). Game-themed programming assignment modules: A pathway for gradual integration of gaming context into existing introductory programming courses. *IEEE Transactions on Education*, *54*(3), 416–427.

Tsukamoto, H., Takemura, Y., Nagumo, H., Monden, A., & Matsumoto, K. (2013). The effects of teaching material remediation with ARCS-strategies for programming education. In *Frontiers in Education Conference, 2013 IEEE* (pp. 717–723). IEEE.

Wang, A. I., & Wu, B. (2015). Use of game development in computer science and software engineering education. *CooperK. ML ScacchiW.(Eds.), Computer Games and Software Engineering*, 31–58.

Computer Science Education Stats (n.d.). Retrieved October 13, 2018, from https://code.org/promote

Wu, B., & Wang, A. I. (2012). A guideline for game development-based learning: a literature review. *International Journal of Computer Games Technology*, *2012*, 8.

Appendix A
Module contents

Module Chunks	Goals	Contents	Coding Concepts	Estimated Time
Stage 1	Getting Started with Game Programming	• Coding environment • Adding a background image		10 min
Stage 2	Building Platforms	• Adding images to the screen • Applying physics to sprites • Adding sprites to a game	Commands and Sequence	10 min
Stage 3	Controlling the Fox	• Using events and conditions to control sprites	Conditional statements	15 min
Stage 4	Adding Animations	• Adding the animation to the fox using a sprite sheet.		10 min
Stage 5	Creating a Ghost and Gems	• Adding more sprites with looping	Looping	15 min
Stage 6	Defining Game Rules	• Displaying a score text on the screen • Defining game rules	Functions	10 min

Appendix B
Recruitment email

Interested in Game Development?

Learn Programming and Get a Starbucks Gift Certificate*!

Aloha! My name is Genta Togashi. I am a graduate student at the University of Hawai'i at Mānoa in the Department of Learning Design and Technologies. As part of the requirements for earning my graduate degree, I am doing a research project.

I built a game development-based instructional module to provide motivational introductory programming experience and am looking for participants to test the module. I am asking you to participate because you are currently enrolled in or have completed LTEC 112 and has sufficient technical background to try the module.

If you participate in this project, you will be asked to go through the online instructional module and work on coding activities. After completing the lessons, you will be asked to fill out a survey. It will take about 1-2 hours to complete entire activities. You can complete this online module and survey anytime at your convenience.

If you are interested, please email me at genta@hawaii.edu before 01/xx/2018. Please let me know if you have any questions.

Thanks,
Genta

* Subject to limited availability

Appendix C
Recruitment flyer

Appendix D
Informed consent

Aloha! My name is Genta Togashi and you are invited to take part in a research study. I am a graduate student at the University of Hawai'i at Mānoa in the Department of Learning Design and Technologies. As part of the requirements for earning my graduate degree, I am doing a research project.

What are you being asked to do?
If you participate in this project, you will be asked to go through the online instructional module provided, work on coding activities, and fill out a survey.

Who can participate in this project?
You must be 18 years old or older to participate in this project. You also need access to a computer with Chrome web browser and high-speed internet to access the online instructional module.

Taking part in this study is your choice.
Your participation in this project is completely voluntary. You may stop participating at any time. If you stop being in the study, there will be no penalty or loss to you.

Why is this study being done?
The purpose of this instructional design project is to design and evaluate a game development-based instructional module to provide motivational introductory programming experience for undergraduate students at University of Hawaiʻi at Mānoa. I am asking you to participate because you are currently enrolled or have completed LTEC 112 and have sufficient technical background to try the module.

What will happen if you decide to take part in this study?
If you decide to take part in this study, you will be asked to go through the instructional module provided and work on coding activities. After completing all the lessons, you will be asked to fill out a survey. It will take about 1-2 hours to complete entire activities. You can complete this online module and survey anytime at your convenience as long as before XX/XX/2018 midnight.

What are the risks and benefits of taking part in this study?
I believe there is little risk to you for participating in this research project. You may become stressed or uncomfortable answering any of the survey questions. If you do become stressed or uncomfortable, you can skip the question or take a break. You can also stop working on the instructional module and taking the survey or you can withdraw from the project altogether.

You may benefit from joining this study as they will be able to experience game programming, and it will be a great addition for your technology competency.

Confidentiality and Privacy:
I am going to assign a participant ID, i.e., P0001 to you, so please use this ID to access the instructional module and submitting a survey. I will not ask you for any personal information, such as your name or address. Please do not include any personal information in your survey responses.

We will keep a database of the participant ID and your names and E-mails and will only use for communicating with you, i.e., troubleshooting or sending follow up emails. The database file will be kept in an encrypted and password protected computer. Only my University of Hawai'i advisor and I will have access to the information. Other agencies that have legal permission have the right to review research records. The University of Hawai'i Human Studies Program has the right to review research records for this study.

Compensation:
A limited number of Starbucks gift certificates are available for encouragements to join the study and will be given to participants on a first come first serve basis. The number of available gift certificates will be displayed in the landing page of the instructional module website, so you can decide whether you want to start or continue the module based on the availability of the gift certificates. If you are awarded, I will send you an e-mail with a link to a gift certificate.

Future Research Studies:
Even after removing identifiers, the data from this study will not be used or distributed for future research studies.

Questions:
If you have any questions about this study, please call or email me at 808.216.2970/genta@hawaii.edu. You may also contact my faculty advisor, Dr. Grace Lin, at 808.956.9989 gracelin@hawaii.edu. You may contact the UH Human Studies Program at 808.956.5007 or uhirb@hawaii.edu to discuss problems, concerns and questions, obtain information or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

To Access the Course: Please go to the following web page:

https://go.hawaii.edu/coding_module

You should find a link and instructions for completing the instructional module and survey. Logging into the instructional module implies your consent to participate in this study.

Please print or save a copy of this page for your reference.

Mahalo!

Appendix E
Survey questionnaire

Coding Module Feedback Form

1. **Please enter your participant ID.**

_____

Demographics

2. **What is your gender?**
Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to respond
- ◯ Other: _____

3. **What is your age range?**
Mark only one oval.

- ◯ 18-20
- ◯ 21-29
- ◯ 30-39
- ◯ 40-49
- ◯ 50-59
- ◯ 60 or older
- ◯ Prefer not to respond

4. **What is your class status**
Mark only one oval.

- ◯ Freshman
- ◯ Sophomore
- ◯ Junior
- ◯ Senior
- ◯ Graduate student
- ◯ Other: _____

5. **Which college are you currently enrolled?**
Mark only one oval.

- ◯ College of Arts and Humanities
- ◯ College of Languages, Linguistics & Literature
- ◯ College of Natural Sciences
- ◯ College of Social Sciences
- ◯ College of Business
- ◯ College of Education
- ◯ College of Engineering
- ◯ College of Tropical Agriculture and Human Resources
- ◯ School of Architecture
- ◯ School of Hawaiian Knowledge
- ◯ School of Law
- ◯ School of Medicine
- ◯ School of Nursing and Dental Hygiene
- ◯ School of Ocean and Earth Science and Technology
- ◯ School of Pacific and Asian Studies
- ◯ School of Social Work
- ◯ School of Travel Industry Management
- ◯ Other: _____

Technology Background

6. **Have you ever written any computer programming?**
Mark only one oval.

- ◯ Yes
- ◯ No

7. **How would you rate your computer skill?**
Mark only one oval.

	1	2	3	4	5	
Novice	◯	◯	◯	◯	◯	Advanced

8. **Which of the following applications, you have personally used and are familiar with?**
Check all that apply.

- ☐ E-mail
- ☐ Web
- ☐ Chat
- ☐ Word Processing
- ☐ Spreadsheet
- ☐ Presentation
- ☐ Other: _____

9. **How do you like playing video games?**
Mark only one oval.

	1	2	3	4	5	
Do not like or never played	◯	◯	◯	◯	◯	Love it

10. **What type of video games do you like to play?**
Check all that apply.

- ☐ Action
- ☐ Adventure
- ☐ Role-playing
- ☐ Sports
- ☐ Simulation
- ☐ Sandbox
- ☐ Strategy
- ☐ Puzzle
- ☐ Other: _____

Module Evaluation (Part A)

11. **Mark only one oval per row.**

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The content of this instructional module was interesting.	◯	◯	◯	◯	◯
I felt I wanted to learn more programming topics while working on this learning module.	◯	◯	◯	◯	◯
I was able to maintain my interest throughout this instructional module.	◯	◯	◯	◯	◯
Each lesson of this learning module had clear goals.	◯	◯	◯	◯	◯
The content of this module matched to my interests.	◯	◯	◯	◯	◯
The content of this instructional module was familiar to me.	◯	◯	◯	◯	◯
This module was able to assist in building a positive experience for success.	◯	◯	◯	◯	◯
Lessons I have learned in this module will lead to my future success.	◯	◯	◯	◯	◯
I was able to learn programming based on my efforts and abilities.	◯	◯	◯	◯	◯
I will be able to use what I have learned in this module in the future.	◯	◯	◯	◯	◯
This learning module provided reinforcement to my success.	◯	◯	◯	◯	◯
My accomplishment was fairly treated.	◯	◯	◯	◯	◯

Module Evaluation (Part B)

12. **Before working on this instructional module, please rate your motivation level in learning about computer programming.**
Mark only one oval.

	1	2	3	4	5	
Not Motivated	◯	◯	◯	◯	◯	Very Motivated

13. **After working on this instructional module, please rate your motivation level in learning about computer programming**
Mark only one oval.

	1	2	3	4	5	
Not motivated	◯	◯	◯	◯	◯	Very motivated

14. **Before working on this instructional module, please rate your interest in learning computer programming topics.**
Mark only one oval.

	1	2	3	4	5	
Not Interested	◯	◯	◯	◯	◯	Very Interested

15. **After working on this instructional module, please rate your interest in learning computer programing topics.**
Mark only one oval.

	1	2	3	4	5	
Not Interested	◯	◯	◯	◯	◯	Very Interested

16. **Before working on this instructional module, please rate your confidence level in computer programming.**
Mark only one oval.

	1	2	3	4	5	
Not Confident	◯	◯	◯	◯	◯	Very Confident

17. **After working on this instructional module, please rate your confidence level in computer programming.**
Mark only one oval.

	1	2	3	4	5	
Not Confident	◯	◯	◯	◯	◯	Very Confident

18. **Before working on this instructional module, please rate your understadning of programming.**
Mark only one oval.

	1	2	3	4	5	
Not Inclined	◯	◯	◯	◯	◯	Very Inclined

19. **After working on this instructional module, please rate your increase of understanding of programming.**
Mark only one oval.

	1	2	3	4	5	
Not Improooved	◯	◯	◯	◯	◯	Very Improooved

Module Evalution (Part C)

20. **Please rate your overall experience with this learning module.**
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

21. **Please tell us what worked well.**

22. **Please tell us what did not work so well.**

23. **Anything else you want to tell us?**

Appendix F
Follow-up message

For participants awarded a gift certificate

Thank you for taking the time to try and evaluation the instructional module.

The information you gave us will make a valuable contribution to the study so that I can build a better instructional module for more students to interested in computer programming.

Here is a link to $5 Starbuck gift certificate, please proceed to the following link to redeem the certificate.
https://startbucks.com

If you have further questions, please email at genta@hawaii.edu.

Thanks,
Genta

For participants not awarded a gift certificate

Thank you for taking the time to try and evaluation the instructional module.

The information you gave us will make a valuable contribution to the study so that I can build a better instructional module for more students to interested in computer programming.

If you have further questions, please email at genta@hawaii.edu.

Thanks,
Genta

Appendix G
CITI certificates

CITI PROGRAM

Completion Date 24-Aug-2018
Expiration Date 23-Aug-2021
Record ID 28246616

This is to certify that:

Genta Togashi

Has completed the following CITI Program course:

Information Privacy Security (IPS) (Curriculum Group)
Exempt Researchers and Key Personnel IPS (Course Learner Group)
1 - Basic Course (Stage)

Under requirements set by:

University of Hawaii

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?wfaa9ae3c-f17c-41ee-8334-d03a75e983d6-28246616