Game Development as a Pedagogical Methodology in Learning Related ICT Skills: Perspectives of Freshmen from FEU Institute of Technology

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Abstract—**Video games have been long established to be an effective educational tool to engage learners in the process of active learning. However, few studies have been performed to investigate the outcomes of employing game development, rather than video games per se, in the classroom. This posed a large gap in the existing body of literature of integrating the game industry into the education sector. Thus, this study served to address this gap, and argued that game development could serve as a pedagogical methodology much like video games for introducing related Information and Communications Technology (ICT) skills such as programming and multimedia topics, among other things. Conducted over three consecutive trimesters, this study explores game development as an educational tool in promoting the development of related ICT literacy skills among freshmen students in addition to the learning acquisition of the game development itself. More specifically, this exploratory-descriptive study sought to investigate how game development fits within the realm of learning ICT topics, and which of the following do freshmen find essential in developing their own original 2D web game. The findings show that game development, when used as a pedagogical methodology, poses the same potential just like any other educational tool used in a learning environment. While it warrants for more validation, the results of this study should be enough to give educational leaders and educators something to consider as to whether integrating game development in learning ICT concepts is worth the try or not.**

Keywords- Video Game, Game Development, Game Engine, ICT Literacy Skills, Information and Communications Technology

I. INTRODUCTION

Albeit it is still not totally accepted across the education landscape yet due to a number of factors like ease of use, usefulness, learning opportunities, and personal video game experience in general [1], the employment of video games as an educational tool has been long proven to be an effective pedagogical methodology in generating a fun and enjoyable learning environment to engage students in the process of active learning [2], and reinforce knowledge on course topics that are typically learned in the classroom [3, 4]. Generally, there are three ways on how video games are incorporated in the traditional classroom setup [5, 6]. First, video games are used as a replacement to traditional classroom exercises [7, 8]. Second, video games are played during lecture discussion to enhance class participation [9, 10]. Lastly, students make their own video games to learn and master related computing concepts and skills [11]. Nevertheless, few studies have been performed to investigate the outcomes of employing game development, rather than video games, as an educational tool in the classroom. This posed a large gap in the existing body of literature of mixing the game industry into the education sector. Therefore, this study served to address this gap, and argued that game development could serve as a pedagogical methodology much like video games in education.

As much as game development has evolved over the last decades [12], the central fundamentals of developing a video game from project initiation to game publication stage have remained generally similar. In a nutshell, game development is commonly defined as a process of creating a video game where the task efforts are assumed by a single or a team of developers. In a deeper interpretation, it can be considered as a hybrid field where it necessitates a cooperative process that depends on various disciplines [13] such as mathematics, physics, computer science, software engineering, production, and marketing, as well as other associated Information and Communications Technology (ICT) skills such as animation, basic programming theories, game design, visual graphics, audio design, and promotional website production .

II. RESEARCH AIMS

This study therefore is focused on realizing whether game development has a potential to be a computer-based didactic tool in introducing ICT related skills to freshmen of FEU Institute of Technology during their CCS0001: Introduction to Computing course where the overview of future courses in the curriculum and the ICT skills to be acquired on each course is being briefly discussed. The research ground of this study was constructed around the premise that teachers should be encouraged to contemplate about critical teaching concepts and principles to develop and promote alternative teaching strategies [5]. This research also sought to find out the perspectives of freshmen pertaining to the use of game development as an educational tool to introduce ICT related skills. While the measurement of learning will be conducted

in the next installment of the research study, the perspective of freshmen concerning the potential of game development in learning skills will serve as a warrant whether the next part of the paper will be pursued or not. For this study, ICT related skills that were discussed and examined were limited on the list given on Table 1. Moreover, the study was also set to explore which of the following skills do freshmen find essential in creating their own two-dimensional (2D) basic game as well as their learning experiences in general during the game activity inside the laboratory class.

TABLE I. ICT SKILLS IN RELATION TO GAME DEVELOPMENT

ICT Skills	Related Game Development Concepts
App Development	Responsive web game, mobile-ready game user interface, mobile app development.
Programming	Gameplay logic, player skills, scoreboards, game menu selection.
Animation	Sprite sheet animation, animated characters and environments.
Visual Design	Game user interface, character design, game world design.
Audio Design	Game sound cues, Background music, Preloaded sound effects.
Website Creation	Promotional game website, HTML5 game script, CSS web design.
Software Deployment	Native app publication, multi-platform computer-based video game.
Cloud Computing	Storage of web games in a cloud, game iteration using cloud tools.
Networking	Online multiplayer game mode, LAN multiplayer game mode.
I/O Devices	Device integration such as joystick, gamepad, controller and dual monitor.
Multimedia Systems	Locating, editing, and/or adding media files such as video, audio, and images.

III. MATERIALS AND METHODS

The study employed exploratory-descriptive design that utilized two different approaches: the exploratory study that was focused on traversing relatively unexplored area to which the approach is supported by Nieswiadomy [14] and a descriptive study is best suited when the information is inadequate and not accessible on a certain topic to which the approach is sustained by Bickman, Rog and Hedrick [15]. This research sought to find out the attitude of freshmen towards the use of technology, their learning experiences, and perspectives pertaining to the use of game development as an educational tool to introduce related ICT skills.

A. Instructional Material

1) Game Engine

During their freshmen years, most students are probably not skilled and knowledgeable yet when it comes to game development especially those students who are enrolled in a non-game related specialization. Therefore, a game engine that is designed for beginners is needed in order for students to develop a game even with limited skills. The main idea behind game engine is to expedite the extensive and highly demanding process of game development [16]. Game engines are now popular because people with limited coding skills are starting to emerge in developing games.

Figure 1. Construct2 2D Game Editor.

Construct2 [17] is one of the powerful game creators that allows anyone to design and build two-dimensional games which can be exported to various web languages (HTML, CSS, JavaScript) and published on the web as native apps. Through its inbuilt layout editor, students can develop their own working game prototype in no time. It was the chosen game engine because of its powerful features that can allow freshmen students, the target sample for this study, to do game development even with limited prior skills.

Figure 2. Game play specification in Construct 2.

2) Game Activity

During the laboratory activity, the students were given a task to create their own 2D Platform Game using Construct2 which can be either modeled to the previously discussed example (Helicopter Game) or based on one of the tutorials on the Construct 2 website to form something entirely original. The basic game screens that were required for students are the following: (1) a home screen with play button and instructions on how to play the game, (2) A 'game over' screen that displays the scores of the players and a button to restart the game, (3) gameplay screen with background music, sound cues, and animated characters.

TABLE II. SAMPLE PROGRAMMING CONCEPTS REFLECTED IN USING CONSTRUCT2 IN DEVELOPING THE GAME

Step	Programming Concept Reflected
1	Initialize identifiers (variables, methods, classes)
2	Use and/or input from keyboard, touch, mouse and joystick
3	Loop constructs and its program iterations
4	Move objects based from a condition
5	Instantiation of a new object
6	Logical decisions
7	Destruction of objects when no longer in use
8	Comparison of logical structures and output display

Students were also encouraged to come up with additional features such as background game music, collision detection and randomization of game world specifically on platform design. Specifying the game play in Construct 2, as shown on Figure 2, the workflow discussed the core programming constructs including the creation of instances in objects, program logic and transfer of control as listed on Table 2. The researchers used a validated rubric based on modern techniques, skills, and tools of computing practice in order to assess the final game project and its quality according to the performance indicators. Students were able to learn the programming concepts and apply the ICT knowledge to the activity with a variety of multimedia contents. Moreover, there were also non-ICT skills used in the project in relation to a standard game development life cycle, such as planning, marketing, deployment, publication, to name a few.

3) Game Development Tasks

Part of the game activity were game development tasks that should be performed in order to develop the game while familiarizing related ICT skills simultaneously. Table 3 below shows the prearranged development tasks for the given game activity and the related ICT concepts and skills.

TABLE III. ICT-RELATED SKILLS AND CONCEPTS EVIDENT IN GAME DESIGN AND LABORATORY ACTIVITY TASKS

Activity Tasks	ICT Related Skills and Concepts
Designing and developing a two-dimensional web game using Construct 2.	Programming logic and languages, objects, instances, variables
Design splash screen, logo and wallpaper	Multimedia systems, Visual design, basic image editing
Design the game world and character asset	Vector Graphics, Sprite Animation, Gameplay design
Import and edit audio to add it as background music or as a sound cue.	Multimedia systems, Downloading audio files from a library, Editing using the built-in editor
Export the final build of the game for web and Windows Store.	App Development, Website creation, Files and Directories, Compile, software deployment
Publish the game on a promotional website.	Website creation, basic markup tags like <embed>, FTP
Playtest the game on smartphone or tablet.	App development, native versus web applications; user experience
Game files copy from a laptop to a computer with joystick or controller.	Keyboard and controller binding to game settings, I/O devices
Store a copy of the game to the cloud, or other online services.	Cloud computing, website development, file management
Test the game prototype using an emulator.	Software deployment, Emulator, playtesting, app development

4) Game Publication

After performing gave development tasks, students were instructed to publish to the Windows Store and embed the game on a basic game promotional website [18] using a web template. Through construct 2, students were able to export the game as a native app that is qualified to be submitted to Windows Store. A laptop or computer with Windows 8 as the operating system (OS) is not a standard requirement in developing a game in Construct 2 but it can help students to test their game as a native windows app. With this, students were introduced to deploying apps in a platform just like what developers normally do when they are on the job, which in return brings great educational value. Construct 2 allowed students to develop a 2D game that runs as a game app in a browser or other readily-made platforms, prevalent trend and experience of students in the game development that run on multiple platforms and devices [19].
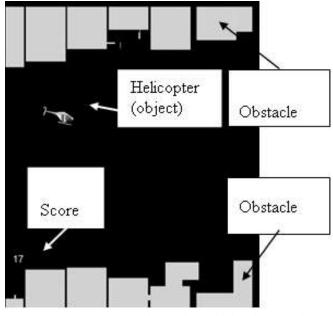

Figure 3. Sample game created by a student entitled "Helicopter" whereas the game mechanics is to fly the helicopter in the game world while avoiding seemless, random obstacles (platform).
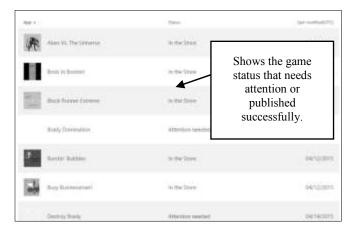

Figure 4. Status of submitted apps in Windows Dev Center.

B. Survey Design

To make use of an existing validated survey tool from any previous research study is the preferred method as this could have provided a comparison of findings with other research papers. Unfortunately, game development is not yet viewed as an instructional tool mainly because it is not a standard skill that teachers would normally acquire as part of their skills set and teaching strategies. Therefore, a locally constructed questionnaire was formulated for this research study that revolves around the perspectives of freshmen regarding the related ICT skills acquired during their laboratory activity which is game development, their attitudes toward technology, and their general ICT literacy experience in game development. Survey questionnaire was pre-tested and trialed by other students which are mean to ensure that the study explanations were adequate. The instrument used in this research study is composed of four criteria. The first criterion explores the students' attitudes toward technology use, in this case, the use of game technology to learn ICT related skills. The second criterion pertains to the students' ICT literacy experiences after developing their game using Construct2 game engine. The third criterion describes the students regarding the ICT related skills in a basic level acquired during the game activity. The last criterion explores and describes the challenges faced by students and the lessons learned by respective teachers pertaining to the game publication to the web and Windows store for future reference.

C. Sampling and Data Collection

For this research, the target population was freshmen from the College of Computer Studies of FEU Institute of Technology who were currently enrolled in the CCS0001/L Introduction to Computing course. To determine the sample respondents, purposive sampling technique [20] was used where respondents was selected based on the population characteristics, study objectives, and the course subject. With the help of CCS0001 professors in their respective classes, 300 students from ten sections of CCS0001 (Lecture) and CCS0001L (Laboratory) courses were privately invited to the temporary classroom in Canvas LMS where the online version of the survey questionnaire was available. Survey was given at the end of each trimester in one academic year to participating class. The purpose of the survey is to gather the perspective of freshmen concerning game development as a vehicle in introducing basic ICT-related concepts. The survey does not intend, in any way, to measure the learning outcomes of the students as this will be the main topic of the next installment of this research study. It was also made clear to students that participating on the survey was not mandatory and will not affect their final grades in any way. Teachers were also advised not to force students to answer the survey. The number of answered questionnaires was 239 (out of 300 invited freshmen in Canvas) indicating a 79.67% response rate.

TABLE IV. SUMMARY OF DEMOGRAPHIC OF PARTICIPANTS

Variables	Category	f	%
Gender	Male	153	64
	Female	86	36
Program and Specialization	BSIT Major in Animation and Game Development	31	13
	BSIT Major in Web and Mobile Application Development	65	27
	BSIT Major in Business Analytics and/or Service Management	24	10
	BSIT Major in Digital Arts	51	21
	BSCS Major in Software Engineering	10	4
	BSEMC Major in Digital Animation Technology	58	24
Availability of Computer at Home	Yes	219	92
	No	20	8
Internet Access at Home	Yes	239	100
	No	0	0
Computer Skill	Novice	123	51
	Intermediate	76	32
	Expert	40	17

IV. RESULTS AND DISCUSSIONS

In this section, the researchers entail to present the results and discussion on each criterion based on the evaluation instrument as answered by the respondents after the game laboratory activity. The discussion explores the students' perspective in terms of the following: attitudes toward technology, ICT literacy experiences, and perceptions of students regarding ICT related skills, as well as the challenges and lessons learned during the game activity.

A. Students' Attitude Towards Technology

Before getting the overall gaming experience [21] and perceptions [22] regarding the ICT skills during a game activity, students' attitude toward the use of technology in learning various concepts were explored first where the results is illustrated in Figure 5. It aims to determine if they are more eager to study and learn when there is a technology available during the discussion or not [23].
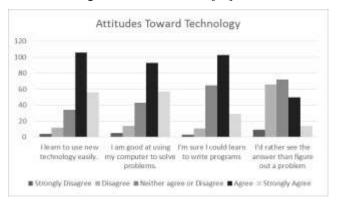

Figure 5. Students' Attitudes toward Technology.

Among the 239 participating respondents, 45% believed that they could learn new concepts easily using technology, 40% affirmed that they are good at using computer to solve various problems, 44% stated that they could learn how to write computer programs when using a technology, and only 19% wanted to see the correct answer to the problem than figure it out on their own. In general, the students' attitude towards the use of technology when learning new concepts is fairly positive which is in accordance with previous study [24]. Moreover, this result was already expected since the respondents are enrolled in a technology-related program.

B. Students' ICT Literacy Experiences

Figure 6 shows the student's experiences during the game activity. ICT literacy is a necessity for students not only in promoting learning processes and outcomes but also for being an active learner on academic environment and lifelong learning settings [25]. Based on the figure, most of students agreed that they were completely able to use the set of ICT skills during learning the game development. With the employment of the skills, 41% of the students approved that they have developed a logical thinking in developing game applications. During the game activity, each student was given a set of tasks for them to experience how to build apps from scratch. With this, 60% of the students agreed that this activity gave them an overview of building applications. Game development was also perceived by 40% of the students as an interesting way to apply IT concepts and 38% of them became interested on future IT courses.
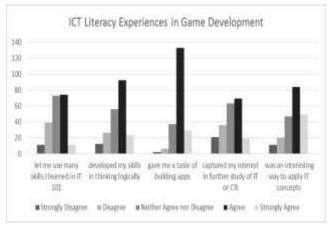

Figure 6.   Students' ICT Literacy Experiences.

C. Students' Perception of ICT Related Skills

Figure 7 shows how students from FEU Institute of Technology perceive skills related in ICT after performing the game activity. Multimedia systems was rated the highest (mean = 4.34) mainly because Construct2 has a built-in layout editor that allowed the students to manipulate media files with ease even though it was their first time to develop a game using such game engine. App development, on the other hand, was rated 4.04 which can be attributed to the last part of the game activity (game publication) as the game

engine has a capability to compile games into different platforms and operating systems, and then to the cloud storage (mean = 3.5). Animation (mean = 4.02) and programming (mean = 4.01) got a mean score close to each other because they go hand in hand in the game activity. This was what students do interchangeably on the activity most of the time since game development requires game logic for the gameplay and sprite animation for the game characters. Mean score for visual design (mean = 3.91) can be attributed to the layout editor of the game engine which allowed students to focus more on the aesthetics of the game rather than how to do it. Since students were required to add background music and sound cues, they were able to explore the audio feature of the game engine. With this, they were able to quickly familiarize the graphical user interface and on how to use it to add game audio and plot it on a conditional structure or in a timeline convincing them to rate audio design as 3.89. Another requirement of the game activity was to embed the game on a promotional website (mean score = 3.79) using a downloaded template. With this, they were able to learn few basic markup tags and were happy to build a simple website in just a few minutes. As part of the additional lesson, I/O devices (mean score = 3.65) such as controller, joystick, and dual monitor were also demonstrated on how to integrate it with their final game. Lastly, networking (mean score = 2.9) was rated the lowest among the ICT skills. Perhaps, the game was focused on a non-multiplayer format and students were not able to try to play a game with multiple players in different devices. Nevertheless, game development showed students on what will comes next on their program and the overview of the concepts needed in order to acquire these ICT related skills.
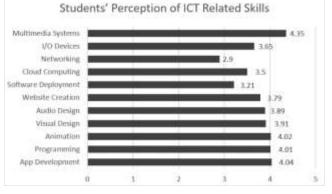

Figure 7.   Students' Perception of ICT Related Skills.

D. Challenges and Lessons Learned

As part of the game activity, students were given a task to deploy their game in two different platforms such as Web and Windows Store. A game promotional website will serve as the home of their game on the web while the app version will be located in the Windows Store. In this activity, there were some challenges and difficulties faced by students which resulted to various lessons to be learned by teachers. These lessons can serve as a guideline for future uses.

1) Publishing games to web

The deployment of student game apps instructions from Construct 2 to web was provided and added pages including the screenshots and descriptions of the games with embed code and link for full game screen to a web page. Students were instructed to save their files in a game folder by the Game Creator. The students encountered the unsuccessful saving of files with the reasons of unexpectedly overwritten and incorrect location with the index.html file format. Students could play and navigate their published websites through web address of the game with the use of any internet browsers and their laptop and/or mobile devices. Students were able to experience playing game applications by adding shortcut apps on the home screens of students' devices with fully-functioning mobile web applications and experience the mobile computing as a developer and creator, not just a consumer. As contended by other researchers, the common issues in teaching programming and computational thinking is beyond the fundamental ideas on how a citizenry can be empowered in the age of information [26].

2) Publishing Games to Windows Store

The biggest challenge to students was to publish game applications to Windows Store and followed the multi-step instructions that shown in the screen-by-screen in Visual Studio that some students was quickly frustrated because of unfamiliarity of the software application and/or the desktop computer was running in Windows 8 operating systems.
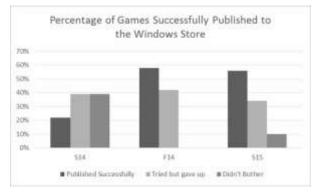

Figure 8.   Games Published on Windows Store.

Students obtain pride in their accomplishments once their games were accepted and boosted students' confidence while adding to their accomplishments that they have successfully published game applications to Windows Store. As stated on comments from the report, some students failed to pass in the certification as they found it truly challenging. In some cases, there was incorrect information in the game description and incorrect publishing process of the apps to an online store but there was nothing wrong with the game itself. Students can give a better performance when acting as a developer where they can use, follow and add learnings to their daily real-world learning lesson to the project beyond the programming skills. Appreciation on the significance of ICT literacy skills to learners were also expressed [27].

V.   OBSERVATIONS AND CONCLUSIONS

During game activity, students required to develop their own game, invigorated by positive feedback by pair and to share individual ideas and review each other's work. It was proved as an effective learning strategy in showing how to achieve several tasks while assisting each other. With the use of online ICT tools, the students can share screens, graphics, or other file to each other, and can create functioning game applications that can completely run in their computer and mobile devices with features like music, score, touch input, animations and other characteristics in real games. On the other hand, students published their games in two different platforms which are accessible on their devices and in turn required the aptitude in applying and identifying tasks to computers and devices. All students under CCS0001 and CCS0001L courses, in which they were enrolled at the time of the study, completed at least a basic game. Students must complete the steps in publishing game applications in Windows Store which requires the support from tutor, faculty member and/or instructor, and the Microsoft evangelists which is not applicable to some students. One of the requirements before publishing a game as native app to the Windows Store is to have a simple task to Microsoft Azure cloud platform. Students configured a virtual file transfer protocol server by publishing to the cloud services that interacts within the Azure portal. On additional note, embedding the game in a learning management system (aside from publishing in an app store) can also be one method in the future especially since e-learning is widely adopted in the Philippines [28].

To conclude, the research findings show that game development, when used as a pedagogical methodology, poses similar potential just like any other educational tool when employed in a learning environment, at least based on the perspective of freshmen from FEU Institute of Technology. While the paper didn't intentionally measure the learning outcomes as it will be part of the future study, the results of this paper warrants the continuation of the future paper to evaluate if game development can enhance student learnings. It is also important to note that the quality of games was mixed across all sections and variations generated diverse results. While the research findings warrant for more validation, the results of this study should be enough to give educational leaders and educators something to consider as to whether integrating game development in lesson delivery within the classroom borders and as a pedagogical methodology of teachers for students to learn ICT related skills is worth it or not. This conclusion thus invites future researchers to validate and test again, and perform a deeper assessment and evaluation of game development about its usage and effectiveness when installed in the education sector.

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