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Game-based APP in Teaching Newton's Three Laws of Motion for High Schools Students

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Abstract: This study aims to design and develop an interactive game-based learning APP for teaching Newton's three laws of motion for High Schools Students and examine students' attitudes towards Secondary Physics and this game-based learning materials. Subjects were 278 students in junior and senior high school. Results indicated that there was a significant difference between pretest and posttest and gender on attitudes toward learning physics ($p < .05$). In addition, the results from interviews with 6 high school teachers showed they were positive toward this software and its effects. Some suggestions for revisions were made from the students and teachers for further improvement.

Keywords: *game-based learning, APP, physics education, mobile learning, Newton's three laws of motion*

1. Introduction

Horizon Report (2012) has forecasted the most promising technologies likely to impact on K-12 education, such as: mobile devices & Apps, tablet computing, game-based learning, personal learning environments, augmented reality, natural user interfaces. Prensky (2001) pointed that the digital game based learning (DGBL) can solve the boring problem in the traditional classroom learning. He further claimed that students grow up along with the technology belonging to "game generation". Education for the game generation is different from that for previous generation. For example, digital games have been reported using in schools in many fileds (Guillén-Nieto & Aleson-Carbonell, 2012; Kennedy-Clark, 2011; Oblinger, 2004; Staiano& Calvert, 2011; Young et al., 2012). Numerous studies also noted that the digital learning will increase students' motivation in learning and enhance their learning performance (Adachi & Willoughby, 2013; Kirriemuir & McFarlane, 2004; Hjert-Bernardi & Anderson, 2011). However, does gamed-based educational app still work in a physics course for a specific topic? This is the key question that we want to get the answer in this study. In this paper, we try to develop a game-based app for students according to the scenario-oriented strategies to learn Newton's Laws of motion. In the beginning, we raised the learning issues of physics courses. Then, we addressed our educational app design for learning the Newton's laws of motion which followed the digital game-based learning (DGBL). Finally, we tested and explained the effects on attitudes toward learning physics with the app.

1.1 State of problem. New technologies have a powerful influence on all aspects of our daily life. Many of them have an impact on the way we teach and learn. There are inconsiderable tendencies, including the reform of teaching models, the trend of information evolution, the convenience of making good use of mobile devices, grasping the advantages of applying technology in learning, and the teaching strategies of combination of challenging hands-on practice and contributing to autonomous learning. At the present time teaching physics in junior and senior high schools is quite challenging. The main problem is that students lack intention of learning in a traditional class; however, they are proficient with computers and interested in new things. It will be helpful to elevate students' intention if the learning environment is built with the technology of virtual reality for students (Parkinson & Hudson, 2002; Shyu & Chou, 2012). Moreover, the basics of physics are complicated and they need more mathematic logic computation. It takes a great amount of time for teachers to explain a phenomena in science ; therefore, students find it strenuous to learn physics. There is deficiency of time,

which troubles teachers while teaching. Students are not able to understand the aim and application of the basics, thus the experimental course will be needed to explain the basics of theories and the utilization of the application. If virtual reality technology is applied to construct 3D related game-based learning, it will be of benefit to students with low learning motivation.

Huang (2009) has pointed out that many physics students in college are familiar with the laws of physics; however, students' practical application of all kinds of basic physics often surprisingly disappoints professors. That may be due to junior and senior high school students' motivation for learning physics is merely for passing the entrance examination. By doing so, it diminishes students' interest in physics and cognition of utilization of physics. In addition, the work effectiveness of applications of simulation software needs verifying. All current simulation software has come into existence for a while and most of them adopted techniques such as Java and Flash. As a consequence, the screen is limited to a 2D range, and fails to display in 3D. There are limitations to show the applications of physics. Moreover, trends of mobile learning and education cloud contribute to mobilization, cross platforms and facilitation of teaching materials.

1.2 Purposes of Study The purpose of this study attempts to carry out an instructional design based on Newton's Three Laws of Motion. A cross-platform game-based material APP using 3D virtual reality technology is designed and produced. It is hoped that students can learn physics in a game-based virtual environment on cross-platform with a mobile device so that learning can be vivid and interesting, which elevates junior and senior high students' motivation for learning physics. Thus, it is hoped that the junior and senior high students receive an experimental instruction so as to acquire the understanding of how the product contributes to their physics learning and what attitude they have towards the physics game-based material. The aims of this paper are threefold: 1. to develop appropriate physics game-based APP -*The Newton Rabbit:* Newton's Three Laws of Motion; 2. to examine the feasibility of the product, e. g., to examine the change of students' attitude towards learning physics and the teachers' acceptability of the product and suggestions; 3. to explore the differences of the students of different genders after the students learning physics through physics games.

2. Game Design

2.1 Game Scenario *Newton Rabbit* is a scenario-based educational APP for learning Newton's three laws of motion. It starts with a story of a crowd of rabbits living on the moon. They have to apply Newton's laws in order to defeat the soldiers on earth, accomplish the tasks and then back home. In the end of the game, the result was shown to either fail or success, including the number of rabbits succeeded to return to the Moon. The software is intended to motivate high school students' interests and problem-solving abilities in learning science.

2.1 Game Features Newton's Rabbit, was mainly developed from the game-based learning design principles based on literature review. The game itself has an easy and intriguing plot with three stages. Students can increase their pleasant experience of learning through games. The complexity of learning physics, in traditional classroom, often makes students lose their motivation for learning it; therefore, the playability and challenges were taken into consideration while the game was designed. For example, (Shown in Stage One) players will face a challenge that they have to know how to launch the rabbit to the moon accurately. Accordingly, players explore and acquire the understanding of the theory of F=MA and of application of the theory as well. After players get engaged in the game and gain a sense of achievement so as to enhance their motivation. In a traditional learning process, a teacher usually lectures along with numerous exercises. In the long run, students merely know how to calculate instead of acquiring knowledge. This app (Newton's Rabbit) emphasizes the discovery and exploration of the relationship between variables through interaction. Therefore, conflicts and choices were designed. For example, the Newton Rabbit in Stage Two, players need to choose to move the rabbit to face the bullets attacking and use the law of reaction to eliminate the bullets from the enemy. In this case, the back and forth design can help students understand and attempt to explain the importance of the reaction force in this stage. Players have the rabbits block the bullets and remove the enemy through the feedback loops. In addition, students are assisted in setting a goal to make the rabbit come back to the earth from the moon in the last stage (Stage Three) so as to gain rewards. This work embedded the knowledge

concepts in the game. Not only can students understand Newton's Three Laws of Motion by completing game stages, but the learning process can be elaborated in a competitive atmosphere in order to gain a satisfying evaluation and reach an educational goal via entertainment. This app (Newton's Rabbit) is a cross-platform game whose system supports computers, smartphones and tablets. We summary the features of this material as following:

1. The screen layout is so vivid that it can attract students' attention.
2. The characters-goofy looking rabbits are so cute that players cannot help but fall for them.
3. The way of playing a series of stage games makes students think and apply the knowledge of physics
4. The instructions, most of which can be carried out with a finger (on a mobile device) or with a mouse (on a computer), are easy and clear. Hence, students can get the hang of it rapidly.
5. The design with multi-versions enables students to play it at home or download it to a mobile device to enjoy it anytime anywhere.

Figure 1. Starting the Game

Figure 2. Stage one- Newton's Second Law of Motion

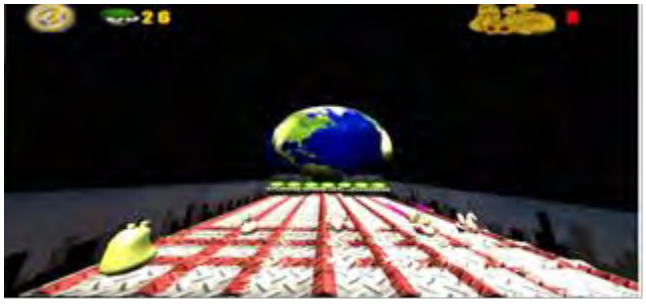

Figure 3. Stage two-Newton's Third Law of Motion

Figure 4: Stage two Newton's Third Law of Motion

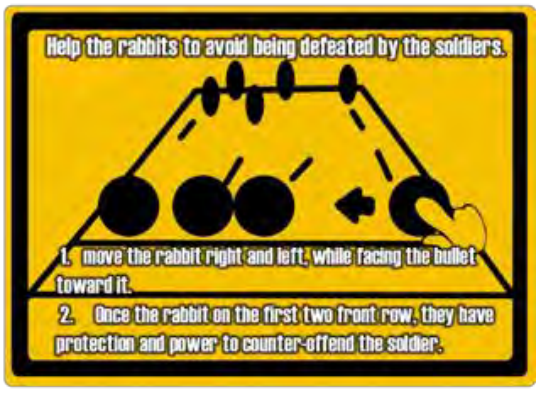

Figure 5. Instructions for Stage Two

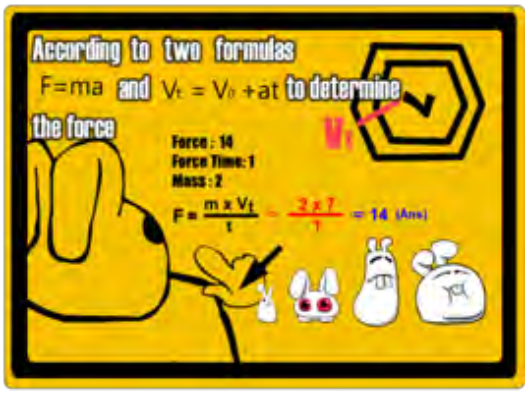

Figure 6. Instructions for State One

3. Research Design

The design-based research was applied to develop Newton Rabbit using ADDIE model. The App was developed by Unity 3D, 3DMaxTM, and PoserTM. Then, the questionnaires were administered before

and after the instruction. The participants in this experiment were 278 students from 8 high schools in Taiwan.

4. Results

4.1 Attitudes toward Learning Physics. Subjects were adminstred bothe before an after the treatment with the questionnaires of a pretest and posttest on attitudes towards learning physics. The prestest was 3.11，and the posttest was 3.93，indicating most of sutdents had a postive attitudes toward physics. The results of a corelated t-test revealed that students's attitudes toward learning physics significantly improved after learning with Newton Rabbit ($p<.05$).

Table 2 : Pretest and Posttest on Attitudes toward Learning Physics

		Mean	Std. Dev.	Prob.
Attitudes toward learning Phyics	Pretest	3.11	0.91	0.00**
	Posttest	3.93		

** p < .001

A further investigation was found that most students liked Newton Rabbits because it was interesting, can enhance motivation, and enjoy the way of this learning. Students also expressed Newton Rabbit can help them learn phyiscs and would like to try more Apps like Newton Rabbit.

Table 3 Posttest on Attitudes

Items	Mean	Std. Dev.
「Newton's Rabbit」make learning physics more interesting	4.04	.95
「Newton's Rabbit」enhance my learning motivation	3.93	.98
「Newton's Rabbit」help me less afraid of learning physics	3.80	1.02
I am willing to spend more time on learning physics with「Newton's Rabbit」.	3.72	1.06
「Newton's Rabbit」help me understand the principle of Newton' laws.	3.86	.93
I enjoy the way of learning physics with 「Newton's Rabbit」	4.05	.97
I would like to try more activities of Apps in learning physics like 「Newton's Rabbit」.	4.04	.92
Over all, 「Newton's Rabbit」helps me learn physics in a better way.	3.96	.95
Average	3.92	.97

4.2 Gender Differences in Attitudes toward Learning Physics with APP. The results of a t-test between gender incated there was a significant difference ($p.<05$). The girls felt more positive toward learning physics with APP than the boys.

Table: Gender difference on Attitudes

	gender	Mean	Std. Dev.	Prob.	Mean
Gender	Male	3.87	.926		0.002**
	Femail	4.02	.709		

**P< .001

5 Conclusions and Suggestions

This study attempted to awaken teachers' attentions to the effects of a game-based APP in assisting middle school students to learn physics-Newton's Three Laws of Motion. The results, which were based on empirical evidences and interviews with teachers and students, have been shown very positive. It is explained that the scenario-and- game-based APP has helped students learn physics and promote physics education in middle schools. Moreover, boys are usually more familiar with game-based software than girls, and they have an advantage of the (positive) learning attitude over girls. This study

indicated that this kind of game-base APP for learning physics is popular with girls, and girls' positive attitude is better than boys'. As a consequence, the results of the study have suggested that the future of game-based software is promising. Meanwhile, Taiwan's government has been promoting the educational apps market to K-12 schools. The results of the present study yielded from the experience of research and students' feedbacks on the APP can offer an example of the development of design and application to educational technology industry, including game-based learning software, application of school education, and textbook publishers, and instructional material designers. It is hoped that the game-based learning APP can be applied on a large scale.

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