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Use of Program Codes to Learn Mathematics and Sciences – A Study on the Effect of Positive Emotions on the Learning of Digital Native Generation

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Abstract: *This study integrated the 3D graphic animations for mathematics and sciences designed by Python and VPython with the methods of cooperative learning to conduct teaching experiment. A mixed scale (Likert 5 point + 10-point + structural items) was used to collect data. Multiple regression analysis was conducted to verify the path of effect of positive emotions on the overall teaching model and learning confidence. The verification results showed that positive emotions have a direct effect of .533 on learning confidence. Learning attitude and cooperative learning have an indirect effect on learning confidence (.430 and .253, respectively). Positive emotions have a total effect of 1.216 on learning confidence. According to the verification results, in addition to affecting learning confidence through teaching model, positive emotions directly affect learning confidence. Therefore, to the learners of digital native generation, positive emotions have an effect of improving their learning confidence.*

Keywords: *Mathematics and sciences education, learning confidence, Positive Emotions, Digital natives generation, 3D images.*

1. Introduction

Taiwanese students won the champion in the mathematics group in PISA 2006 (Programme for International Student Assessment). However, PISA 2009 announced that Taiwanese students' performance in the mathematics group dropped to 5th place (PISA, 2010). The gap of mathematics literacy of higher graders also gradually expanded. The Index of Students' Self-Confidence in Learning Mathematics (SCM) was lower than the international average. Therefore, students lack self-confidence when assessing their performance in mathematics [13]. Under the traditional education system, teaching materials and teaching approaches in Taiwan, students lack self-confidence in learning mathematics and are even anxious about it. According to the teaching observation by Tseng (2010) [22], most of the students like to use their own approaches to solve mathematics problems and express their views on mathematics. However, they hate mathematics when facing mathematics examination.

2. Research Motives and Purposes

Young students who are mostly born after the 1980s are known as the digital native generation [18]. Compared to the learners of the last generation, those of the digital native generation have more opportunities to be exposed to various digital information technologies and are more accustomed to image stimuli. The learners of the current generation in Taiwan are exactly the generation whose self-confidence is lower than international average. Therefore, the research motive is to develop an approach applicable to students of the digital native generation to learn the knowledge of mathematics and sciences, in order to help them to regain the self-confidence in learning mathematics.

Based on the research motive mentioned above, this study developed 3D computer animations/images in the hope that this animation-assisted teaching strategy can help students regain self-confidence in learning the knowledge of mathematics and sciences, which is the main research purpose.

3. Literature Review

3.1. Characteristics of Digital Native Generation

During the schooling process, the digital native generation has been exposed to a lot of digital learning contents. Students can obtain instant social messaging & feedback and abundant graphical

interfaces using social software and websites, such as instant messaging and Facebook. In addition, they concurrently use the windows of their assignment and those for searching for information, leading to the phenomenon that learners are accustomed to image stimuli, working model of parallel processing and instant feedback [6]. Therefore, Collins & Halverson (2009)[7] suggested that the created learning environment for the digital native generation should possess characteristics of instant learning, interaction, learner control, reflection, etc. This study intends to develop a teaching model which is applicable to students of digital native generation and can improve their self-confidence in learning mathematics.

3.2. Benefits of 3D Animations/Images to the Learning of Mathematics and Sciences

The advances in information technology, popularity of computer, and the ability to rapidly process, store and transmit all kinds of information improve the working efficiency of people. Moreover, the advances in multimedia technologies refine the processing of various image and animation effects. If multimedia can be used for the learning of mathematics and sciences, students' learning effectiveness can be improved. 3D animations/images are the new application of multimedia technology, and can be used as a new channel for learning mathematics. The learning effectiveness of general learning mathematics is assessed based on examinations. In higher level of examinations, students may have the opportunity to face oral mathematics examinations of thinking dialogues. However, they do not have such an opportunity in general mathematics examinations. This study intends to create a visual environment using 3D animations/images, and triggers students' mathematical thinking through the model presented by virtual animation [9].

Yu (2011)[25] selected college freshmen who firstly learned calculus and the sophomores of Department of Mathematics who learned advanced calculus as the subjects, and used the Java 3D teaching model to investigate the teaching and learning of computer-assisted multivariable calculus. Yu connected algebraic characterization with image characterization to establish the significance of differentiability, which made abstract mathematics concepts tangible to students to enable them to develop self-confidence in learning.

Mathematics includes at least two characterization forms – symbols and images. If only symbols are used to characterize mathematics concepts, such concepts maybe excessively abstract and intangible. Zazkis, Dubinsky, & Dautermann (1996)[26] suggested that visualization can develop a strong connection between internal and external characterization. When students intend to learn a complicated mathematics concept, in addition to understanding different characterization, they also have to covert and transfer characterization. Therefore, 3D animations/images can be used to connect courses of different characterization to help students convert and transfer different characterization, to enable them to operate and answer, to stimulate their reflection and to develop internal and external characterization. [23,17,1] Computer module can be used to concretize image or theory on the plane to provide students with perceptual experiences and enable them to construct, combine and restructure image or theory through operation, which helps to form the understanding of mathematics meaning under human-computer interaction[15]. Therefore, based on the literature above, 3D animations/ images are beneficial to the learning of mathematics and sciences.

3.3. Cooperative Learning

Cooperative learning is regarded as a learning group consisting of teachers and students. In such a group, students can learn from one another and develop the mechanism of trust. Basically, cooperative learning is also deemed a group with social functions [20]. Learning achievement cannot be attained until the process of cooperative learning is carefully planned and the learning guided. To successfully implement cooperative learning, the communication among members and the completion of the responsibility are also very important [27]. The existing studies indicated that, with the assistance of computer images and animations, as well as the implementation of cooperative learning, it is easier for students to accept the learning of sciences [2]. As a result, this study used the teaching model combining cooperative learning with computer animation/image to implement the education of knowledge of mathematics and sciences in order to improve students' learning confidence.

3.4. Positive Emotions

In education, positive emotions refer to the delighted and happy mood during learning, and experience of flow may even be developed. The past studies indicated that, people maintaining positive emotions

can create more benefits to health and work, compared to those maintaining negative ones [24]. Kuo (2010)[14] investigated positive emotions from the perspective of education, and suggested that positive emotions enable people to respond to predicaments, develop diversified thinking and trigger their creativity. Some studies even indicated that positive emotions are correlated with positive thinking. Positive thinking refers to people who maintain the attitude of positive, optimistic and aggressive thinking towards themselves and people and things around them [10]. According to relevant studies, learners who are able to maintain positive emotions have more positive thinking. Therefore, their learning attitude and cooperation with classmates and teachers are more aggressive, and their confidence in learning mathematics is more positive.

3.5. Learning Attitude

Attitude refers to people's subjective view and feeling about things. Attitude is even regarded as the key factor affecting actions. If students' learning attitude is investigated from the perspective of education, it can be found that the influence of attitude on learning is not second to that of other personality traits and background factors. When the integration of information into teaching has become a trend of education, the importance of students' learning attitude is investigated again. Taking the internet cooperative learning promoted in recent years for example, Korkmaz (2012) indicated that positive learning attitude is regarded as one of the key factors of successful cooperative learning. He even developed a scale on internet cooperative learning attitude. Therefore, attitude is important to either cooperative learning or e-learning.

3.6. Self-Efficacy and Learning Confidence

Positive emotions indirectly affect learning confidence by affecting cooperative learning and learning attitude. Another factor that affects students' learning confidence during education process is self-efficacy. Self-efficacy refers to the evaluation period in which an individual evaluates to which extent he/she can achieve the expected objective [3, 4].

Self-efficacy is associated with learners' learning confidence. People with high self-efficacy attribute the frustration they encounter during learning to their insufficient efforts. Therefore, they make more efforts to overcome learning difficulties. However, people with low self-efficacy often attribute failure to their lack of ability, and they may not necessarily make efforts to think about how to overcome learning frustrations [8]. If individuals can identify themselves with their own ability, they are people with high confidence. On the contrary, there are people with insufficient confidence. Chang (2011) [5] suggested that confidence refers to individuals' attitude of strong support for what they know and their ability. Huang & Yang (2011)[11] suggested that learning confidence refers to students' trust in their own ability of self-control and self-learning during learning process, as well as possession of the attitude to judge the accurate approaches to complete learning tasks. Their research results even showed that learning attitude affects learners' confidence in learning mathematics, and learning confidence is an important factor affecting learning achievement.

Sander & Sanders (2003) [19] selected college students as the subjects to further associate college students' learning with academic behaviors and extend their learning confidence to the confidence in academic activity achievement. To college students, learning confidence presents "whether they strongly believe that their ability can achieve the expected objective of academic activity." Due to this reason, if learners are not confident in their own ability or assess that their ability cannot achieve the objective of current learning task, they lack learning confidence, cannot devote themselves to the learning of academic activity and may even escape from learning. Therefore, any learning effectiveness naturally cannot be attained [12].

This study combined cooperative learning with 3D image/animation to create a teaching environment where students' learning emotions could be more positive to eventually change their attitude towards learning mathematics and sciences and to enable them to believe that they are able to learn well the knowledge of mathematics and sciences.

4. RESEARCH METHOD

This study suggested that 3D animations could be used to present particle trajectories and tangential velocity, direction and magnitude of mathematics. Moreover, the formulas were specified in the images to enable the learners to understand more easily the concepts of physics kinematics presented using mathematics. The teaching materials combining 3D animation/image with cooperative learning

model developed in this study instructed students in the knowledge of mathematics and sciences in order to improve their confidence in learning mathematics and sciences and develop future learning effectiveness of learning of mathematics and sciences. Based on the investigation of the above literature, in addition to affecting cooperative learning and learning attitude, positive emotions also directly affect learning confidence. Therefore, this study proposed the following hypotheses, and validated whether the use of 3D animations can help students to develop more positive emotions and further improve their learning confidence:

H1: Positive emotions have a direct effect on cooperative learning.

H2: Positive emotions have a direct effect on learning attitude to a certain extent.

H3: Positive emotions have a direct effect on learning confidence.

H4: Positive emotions have an indirect effect on learning confidence through cooperative learning.

H5: Positive emotions have in indirect effect on learning confidence to a certain extent through learning attitude.

H6: Self-efficacy can create learning confidence.

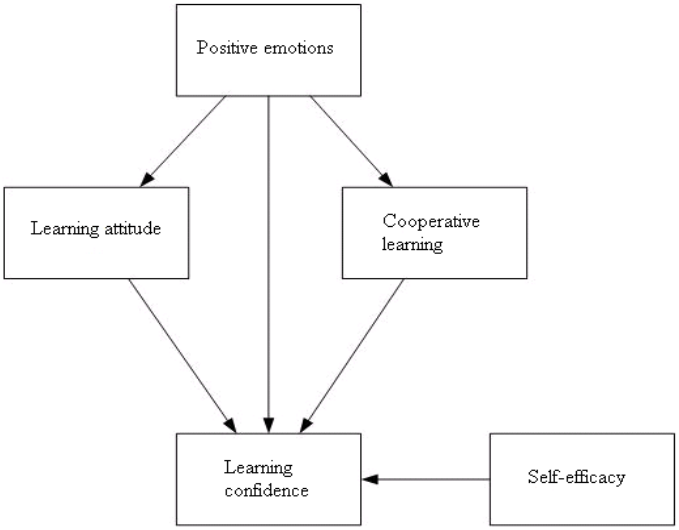

Fig1. *Model Framework*

4.1. Research Samples

This study selected 75 students (aged 18-24) in school of business and management of a certain college in the southern Taiwan who agreed to participate in this study as the subjects. In terms of the gender proportion of the subjects: 36% of them were male and 64% of them were female. In terms of the proportion of schools of the subjects: 10.7% of them were from school of liberal arts, 4.0% of them were from school of education, 1.3% of them were from school of science and 1.3% of them were from school of management. In terms of the proportion of college admission channels of the subjects, 82.7% of them participated in the admission examination, 58.7% of them applied for admission, 22.7% of them were recommended for admission and10.7% of them were transfer students. In terms of the proportion of time of learning of program codes: 8.0% of them learned them for less than 1 month, 45.3% of them learned them for 1 month, 16.0% of them learned them for 1 semester, 38.7% of them learned them for 2 semesters and others accounted for 38.7%.

4.2. Tools

This study used questionnaire survey as research tool. In terms of the questionnaire content design, Likert 5-point scale + 10-point scale + structural items were used. The dimensions of the questionnaire include: self-efficacy, positive emotions, learning attitude, cooperative learning and confidence in learning the knowledge of mathematics and sciences.

Expert interviews were used to adjust the appropriateness of the questionnaire content and themes, scoring and format of the preliminarily designed questionnaire. This study used a mixed scale (Likert

5-point scale and 10-point scale + structural items) for students to complete. Afterwards, the validity and reliability of the questionnaire data and content were analyzed to verify whether the questionnaire data are suitable for the data collection in this study. The SPSS V21 was used to perform multiple regression analysis and verify the effect of positive emotions on learning attitude, cooperative learning and learning confidence. This study also verified the effect of positive emotions on the confidence in learning mathematics through learning attitude and cooperative learning. This study verified the effect of self-efficacy on the confidence in learning the knowledge of mathematics and sciences. In terms of data collection, because the return of qualitative data was included, this study converted the collected data into qualitative data (the parts of positive emotions). According to the definitions investigated in the literature, this study used virtual regression to convert the collected data into qualitative data to facilitate research analysis.

For the data collection of positive emotions, many factors might affect the emotional responses of learners during the research process. The research team has used 3D animation/image to implement the teaching of mathematics and sciences for many years. According to the former teaching experiences, this study designed the factors which might affect students' emotional changes during the teaching experiment as structural items, and used them as the approach to collect the data on positive emotional responses.

After experts' preliminary assessment and reliability and validity analyses of the questionnaire items, 22 items totally were retained. The items of each dimension are as follows:

Self-efficacy: 6 items

Self-efficacy [7. I will not give up when I find anything I don't understand during the learning of principles of mathematics and sciences]

Self-efficacy [6. When I decide to learn the theories of mathematics and sciences, I will immediately start to learn them]

Self-efficacy [5. Even though the principles of mathematics and sciences are very difficult, I still will adhere to learn them]

Self-efficacy [1. When I do not understand the principles of mathematics and sciences, I will try to look for information until l completely understand them]

Self-efficacy [3. I am brave to face difficulties]

Self-efficacy [4. I am willing to solve complicated problems]

Positive emotions: the positive emotions in this study were caused by the "confidence in grasping the knowledge of mathematics and sciences"

Learning attitude: 4 items

Cooperative learning [2. I cannot help but to ask for device from classmates who can design cool images]

Cooperative learning [3. I'd like to form a group with classmates to discuss about which program codes correspond to image changes]

Learning attitude [6. I can better deal with the problems of mathematics and sciences with the assistance of 3D images]

e-learning [3. I am satisfied with the use of 3D images/animations as the tool for learning the knowledge of mathematics and sciences]

Cooperative learning: 5 items

Cooperative learning [11. I will discuss with teacher about how the curved surface is calculated after class]

Cooperative learning [12. I will discuss with teacher about the reason why the color of curved surface changes]

Cooperative learning [13. I will discuss with teacher about the reason why program codes control the thickness of curve]

Cooperative learning [14. I am willing to discuss with teacher about the formula of mathematics and sciences]

Cooperative learning [15. I will discuss with teacher about why the 3D image drawn by the program is different from that on the plane in general textbook]

Confidence in learning the knowledge of mathematics and sciences: 6 items

Level of understanding of the knowledge of mathematics and sciences [4. I can better understand how to interpret images through the 3D animations/images of mathematics and sciences]

Level of understanding of the knowledge of mathematics and sciences [5. I can better understand the occasions for application of knowledge of mathematics and sciences through the 3D animations/images of mathematics and sciences]

Level of confidence in the knowledge of mathematics and sciences [3. By converting the knowledge of mathematics and sciences into images, you believe that you are more capable of dealing with various phenomena and problems]

Level of confidence in the knowledge of mathematics and sciences [5. The use of 3D image of mathematics and sciences in teaching makes you believe that you are more familiar with the mathematics that you have learned before]

Learning attitude [1. I feel that my ability to operate learning program codes is not bad]

Learning attitude [2. When the images produced are not what I want, I will revised them until they become what I want]

4.3. Design of Research Materials

In terms of the design of research materials, this study used the free software Python and vpython to write the program and create 3D images/animations to present various meanings hidden in mathematics and sciences. After choosing ball placement and parabola as the teaching themes of mathematics and sciences, this study enabled students to understand the basic meanings of mathematics presented by animations based on program design and program implementation results. For the writing of programs, teachers could actually instruct students in writing programs in class, including the grammar, structure, control flow and implementation results of programs. Students could observe the different changes in results from various perspectives to enable teacher to achieve the objective of "teaching." In addition to writing the program in class, they could also use actual themes to simulate the condition in real world. They could discuss with teacher at any time when they faced anything they didn't understand. Moreover, students were encouraged to form learning groups to observe one another and investigate how to present the theories of mathematics and sciences. The files and teaching materials were available on the internet teaching platform, and students could download them at any time to achieve the objective of "learning."

"The abstract formula of mathematics that simulates and characterizes dynamics and display visualization" is a long-term problem encountered by students when learning mathematics. The research team includes teacher of Department of Mathematics in college and teacher of engineering mathematics in technological college who investigated the meanings of mathematics and physics and their engineering application values based on this phenomenon. For example, the changes in the parabolic relationship between ball placement and bounce could be presented by writing programs. The vivid animations enabled students to understand more easily its meaning and application values in physics and engineering. During the operation, students could understand:

- Drawing the complete curved images using the 3D animation drawing process to concretize abstract concepts to understand the changes in the relationship between independent variable (e.g. x or y) and dependent variable (e.g. z). The location of xy of maximum or minimum could also be determined based on the curved surface.
- The use of both curved surface and parabolic placement enabled learners to better understand the concepts.

4.4. Procedures of Teaching Experiment

To verify whether the teaching model combining 3D animation/image can effectively improve the confidence of learners of digital native generation in learning the knowledge of mathematics and sciences, the design of the teaching experiment is as follows:

- Teacher demonstrated the 3D image/animation of knowledge of mathematics and sciences (ball placement and parabola), as shown in Figure 2.
- Explaining the corresponding relationship among program codes, image generation and formula of mathematics and sciences.
- Students actually operated the program. During the operation process, students and classmates next to them created different program code effects and exchanged with each other for use.
- Teacher would display the operation screen of some of the students as the examples and guidance on creation direction.
- Students submitted the finished work and completed the teaching questionnaire.

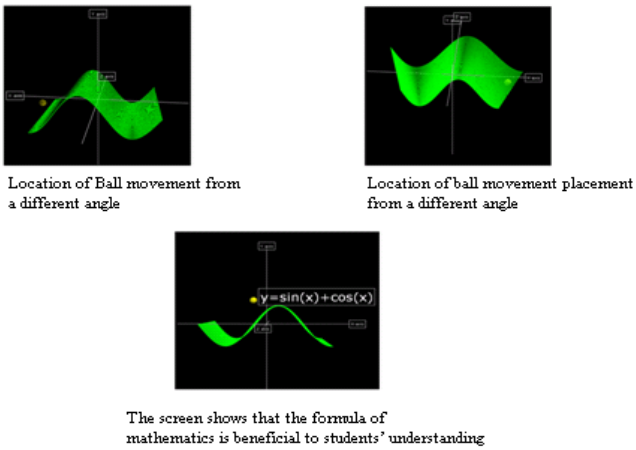

Fig2. *Screen of Presentation of 3D Images/Animations*

5. Verification Analysis and Discussion

5.1. Reliability and Validity Analysis of Questionnaire

Because mixed scale was used, this study performed factor analysis on dimensions to verify the validity of the questionnaire, and then performed reliability analysis to test the reliability of the questionnaire. The dimensions of factor analysis 1 include: learning confidence, cooperative learning and learning attitude. The KMO was .755, reaching the significance. Therefore, it was suitable for performing factor analysis. Table1. is the data of the reliability and validity analyses:

Table1. *Reliability and validity analysis results of learning confidence, cooperative learning and learning attitude*

Factors	Sum of squared loading Variance (%)	Sum of squared loading Total variance (%)	Cronbach's Alpha value
Learning confidence	28.876	28.876	.928
Cooperative learning	26.338	55.214	.940
Learning attitude	21.896	77.110	.911

The dimension of factor analysis 2 was: self-efficacy. The KMO was .903, reaching significance as well. Therefore, it was suitable for performing factor analysis. Table2. is the data of the reliability and validity analyses:

Table2. *Reliability and validity analysis results of self-efficacy*

Factor	Sum of squared loading Extracted variance (%)	Sum of squared loading Extracted total variance (%)	Cronbach's Alpha value
Self-efficacy	84.929	84.929	.985

Based on the results above, the questionnaire applies to this research project.

5.2. Multiple Regression Analysis

Figure 1. is the model framework of this study. In order to answer the 6 questions raised in this study, this study verified the effect on each direction. The effect is shown in Figure 3. The analysis results are as follows:

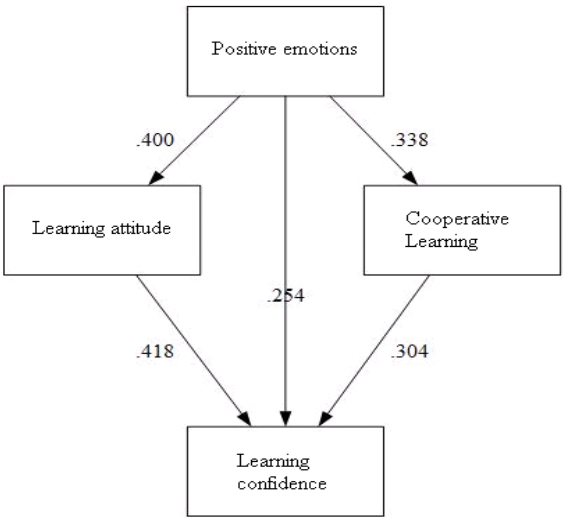

Fig3. *Verification Results of the Model Framework*

According to the final verification results, positive emotions have a direct effect of .400, .338 and .254 on learning attitude, cooperative learning and learning confidence, respectively. The result is consistent with that of literature review, and the research hypotheses H1, H2 and H3 were supported. Positive emotions had an indirect effect of 0.1672 (.400 X.418) and 0.1028 (.338 X.304) on learning confidence through learning attitude and cooperative learning, respectively, verifying the research hypotheses H4 and H5. Positive emotions could reach a total effect of 0.524 (0.254+0.1672+0.1028) through the indirect and direct effects on learning confidence.

According to the said verification results, positive emotions not only affect the effectiveness of cooperative learning and learning attitude, but also indirectly and directly affect learning confidence through them. Therefore, positive emotions indeed are a very important factor, which not only change the effect of learning attitude and cooperative learning, but also is an important factor for improving learners' learning confidence.

However, self-efficacy of H6 fails to affect learning confidence. This finding is different from that of the past studies. The cause of this phenomenon might be the restriction on some of the factors, which leads to the difference between this study and past studies. If relevant future studies can also verify this phenomenon, a detailed investigation can be further performed. The factor which might restrict the verification included: small sample size of research subjects; most of the students were from school of business and management who might be less similar with this theme; the self-assessment on knowledge of mathematics and sciences might be affected by original ability.

6. CONCLUSION

The verification results showed that positive emotions indeed affect the confidence of the digital native generation in learning the knowledge of mathematics and sciences. The teaching model combining cooperative learning with 3D computer animations/images found that the learning attitude towards the use of 3D images/animations as teaching materials and the cooperative learning between peers and teachers both were affected by positive emotions.

In addition to indirectly affecting learning confidence through learning attitude and cooperative learning, positive emotions can also directly affect learning confidence. Therefore, positive emotions are an important factor affecting the learning of knowledge of mathematics and sciences by the digital native generation. To use the teaching model combining cooperative learning with computer animation/image to attain good effect on learning confidence, positive motions are an important factor that cannot be ignored.

6.1. Research Limitations

This study developed a computer animation/image-assisted teaching material which can help learners of the digital native generation to regain the self-confidence in learning the knowledge of mathematics and sciences. To reflect the significant effect of verification results, this study selected students from school of business and management who are weaker in knowledge of mathematics and sciences as the subjects. However, due to the limitation on number of students in the class instructed by the principal investigator and the number of students willing to undergo the questionnaire survey, only75 students were enrolled, which was the main research limitation.

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