A Study on Applying Digital Peer Teaching to Improve High School Students' Learning Achievement

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Abstract

Digital learning has become a trend in the field of education, and it's slowly brewing in senior high school. This study aims to explore the impact of the senior high school students using Information Technology (IT) in digital learning on their learning attitude, self-efficacy, learning strategies and learning achievement.

The data was obtained from two experiments. In experiment 1: 41 students from Hualien High School were divided into experimental group and control group, and subjects in the experimental group were learning by using IT, with 38 valid questionnaires collected. In experiment 2, in order to explore the correlations among math learning attitude, self-efficacy, learning strategies and learning achievements, 348 second-grade students were selected as research subjects. There were 282 valid questionnaires. SPSS and SmartPLS software were the main tools for analysis. The results showed: (1) There were significant differences in learning attitude, self-efficacy, learning strategies and learning achievement. (2) There are significant correlations among learning attitude, self-efficacy, learning strategies and learning achievement. (3) Learning attitude has a significant and positive influence on self-efficacy and learning strategies. (4) Self-efficacy has a significant and positive influence on learning strategies and learning achievement. (5) Self-efficacy is a mediator between learning attitude and learning strategies.

Keywords: Digital learning, Learning attitude, Self-efficacy, Learning strategies, Learning achievement

1 Introduction

1.1 Background and Motivation

The scores that the senior high school freshmen in Hualien County obtained in Comprehensive Assessment Program for Junior High School Students can range from 5B to 5A++, the percentage of students' level can also vary from Pr50 to Pr99. Therefore, it is imaginable that the gap and difference between students in these two extremes [1].

Mathematics is a core academic subject, not just for the domains of science, technology, engineering and mathematics but for nearly all students in nearly any domain. Mathematics Prince Gauss (Carl Friedrich Gauss 1777-1855) once said, "Mathematics is the mother of science" and "mathematics is the key to science". In the process of learning math, the more frustration and anxiety students get, the lower their math achievement will be [2]. Students' understanding and operation in math concepts is crucial to solving many problems in their daily life and future work, and may further hinder their access to science learning that requires deeper and more abstract thinking. How to reduce frustration, anxiety and enhance learning achievement is the motivation for this study.

There are many factors that affect the achievement of learning. Students lacking interest in learning tend to have lower learning effect, which in turn leads to their lower academic achievement. Therefore, in math teaching, there should be another way to facilitate the low math achievement students to learn to increase their successful experience of math learning, and also improve their learning attitude and learning achievement. The e-learning is one of the most convenient ways of learning and is also free from time and space constraints [3-5].

"Understanding is better than listening; teaching is better than understanding" is a saying which explains the learning process and meaning. As Cone of Learning, its various stages have their different meanings [6]. As Figure 1 shows, the students retain the knowledge only 5 to 20% from the lecture to the audiovisual stage. From the demonstration to discuss stage, when the students start to practice solving math questions, they begin to understand, and the average of learning retention rate in this phase increases to 50%. When the students can clearly explain the concept of math to the classmates, the average of learning retention rate can be increased to 90%.

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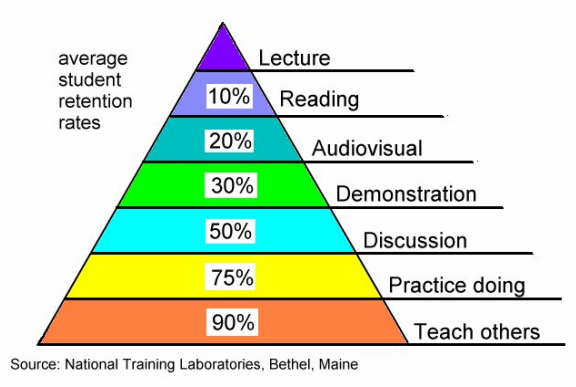

Figure 1. Cone of Learning

Many studies have indicated that learning attitude and self-efficacy have positive correlations [7]; in addition, self-efficacy has the ability to predict learning strategy [8]. Moreover, self-efficacy and learning strategies also have a positive influence on learning [8-10].

Tutorial Video is one of the most common ways used in digital learning [11-12]. It can improve students' math learning attitude, thereby enhancing their learning achievement.

1.2 Research Question and Research Purpose

The research question of this study is: If students are willing to record the video of exercises in digital media, will this have a significant impact on their academic achievement? The researcher will further explore the relationship between learning attitude, self-efficacy, learning strategies and learning achievement. The purposes of the study are as follows:

(1) Differences of students' learning attitude, self-efficacy, learning strategies and learning achievement will be compared. (Experiment one)

(2) Establish learning attitude, self-efficacy, learning strategies and learning achievement structural equation model. (Experiment two)

(3) Explore the relationship between learning attitude, self-efficacy, learning strategies and learning achievements and their impact. (Experiment two)

(4) Based on the results of questionnaires, cluster analysis is used to explore the features of students.

(5) Based on the research results, theoretical and practical suggestions will be proposed.

(6) Based on the research results, students with different characteristics will be understood and different ways will be used to stimulate students' learning attitude.

2 Literature Review

2.1 Learning Attitude

Under the influence of behavioral faction and behavioral theory, Baron and Byme [13] interpret their attitude as a link between attitude object and attitude evaluation, as well as a continual evaluation of various people, things and objects in the world. Mathematical learning attitude refers to the degree of personal preference for math learning. Aiken believes that mathematical learning attitudes are a response to cognitive, emotional or feeling in the process of mathematical learning [14]. It is also an individual's tendency to evaluate math learning. Its connotation includes three parts: cognition, emotion and behavior [15].

2.2 Self-efficacy

The "self-efficacy" theory proposed by Bandura is the core concept of social learning theory: the judgment of individual's self-ability to achieve a specific job; when individuals adjusted their own motivation, the patterns of thinking and behavior, they were controlled by self-efficacy cognitive mechanisms [16]. "Self-efficacy" is "when an individual responds to stimuli, he must take action to measure his ability to cope with situations to show appropriate behavior and, on the other hand." It can be considered whether individuals have the motivation to overcome the obstacles and adopt the tactics to solve the problems in their efforts to achieve the goal by unifying the behaviors [17].

There are a lot of studies on self-efficacy and related education, both in academic performance [18-19], subject knowledge (math, English ... etc.), skills and behavior [20-22]. Self-efficacy not only predicts student motivation and learning achievement [19, 22-23] but also is an important predictor of subsequent success [24].

2.3 Learning Strategies

The strategy is a kind of systematic and planned decision-making activity and is a goal-oriented activity. It must involve the inner psychological process in solving the problem [25]. There are three conditions in strategy formation: the problem situation, cognitive stress and risk [26].

Dansereau [27] divided learning strategies into primary strategies and support strategies. The primary strategies are to assist students to reorganize, integrate and refine their messages. It is used to acquire, store or use the target messages, and the primary strategies have direct learning and promotion functions such as message processing and critical thinking. Support strategies are mainly used to help students develop and maintain a good internal state [27].

2.4 Digital Learning

Digital learning is defined as the use of the Internet and related technologies to develop teaching and to deliver educational resources [28]. The Internet can provide communication channels such as email, Bulletin Board System (BBS) and real-time chat rooms

and etc.. The World Wide Web (WWW) provides web pages with hyperlinks, files, animations, videos, audio and etc.. These different forms of channels are used to show the course content. The Internet and World Wide Web are important infrastructures in digital learning. They provide not only online teaching materials but also mechanisms for electronic communication and interaction between teachers and students [29]. The tools and techniques used in digital learning can record all learners' communication action and interaction in a traditional classroom, and to enhance their personal learning process.

3 Research Methodology

3.1 Research Model and Hypotheses

With the discussion of the literature, the correlation between learning attitude, self-efficacy, learning strategies and learning achievement, the research model proposed in this study is shown in Figure 2.

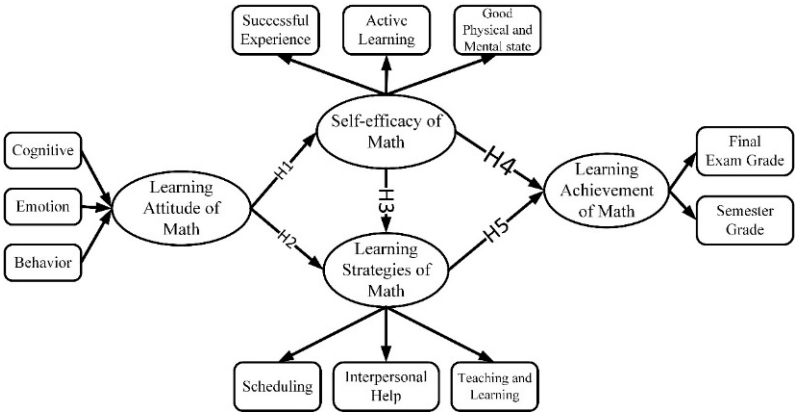

Figure 2. Research model

The following five hypotheses were proposed:

H1: The learning attitude of math had a significant positive effect on self-efficacy of math.

H2: The learning attitude of math had a significant positive effect on learning strategies of math.

H3: The self-efficacy of math had a significant positive effect on learning strategies of math.

H4: The self-efficacy of math had a significant positive effect on learning achievement of math.

H5: The learning strategies of math had a significant positive effect on learning achievement of math.

3.2 Participants and experimental design

Experiment 1 was to understand whether students participating in video recording exercises by using digital media, who in the process became more familiar with the concepts and problem-solving skills of exercises, will show significant improvement their math learning achievement. Experiments 1 used an experimental research design approach. Students who were willing to participate in the recording of videos were assigned to an experimental group (n = 18) and others students were assigned to a control group (n = 20). Finally, whether there was a difference between math learning achievements was assessed.

The first stage of the experiment was from December 12th, 2016 to January 6th, 2017, for 4 weeks. After 4 weeks, all students were asked to fill in the questionnaire with a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). Out of 41 questionnaires collected, 38 valid responses were obtained (92.7 percent response rate).

In experiment 2, it was to explore the correlations between learning attitude, self-efficacy learning, learning strategies and learning achievement. The experiment was from May 15th, 2017 to June 30th, 2017, totaling 6 weeks. 348 second-grade students, including average students and Math and Science Gifted students, were selected as research subjects. There were 282 valid questionnaires.

3.3 Data Analysis

This study used the t-test in the statistical tool SPSS 20 software to detect the differences in learning achievement between experimental groups and control groups. The PLS structural equation model (PLS-SEM) was constructed by using SmartPLS software.

4 Results

4.1 The Experimental Group and Control Group Differences in the Various Facet (Experiment 1)

Before the start of the experiment 1 (Table 1), there was no significant difference between the experimental group and the control group in the performance of the second mid-exam. However, there was a significant difference in the performance of final exam after the experiment 1 (t-value = 2.415, $p < 0.05$), which meant

that during the experimental period, the experimental group of students tried hard to adjust their psychological and physical state, so their performance in the final examination was higher than the control group.

Table 1. t-test analysis of experimental group and control group

		Experimental Group (n = 18)		Control Group (n = 20)		t-value
Constructs	Variables	Mean	S.E.	Mean	S.E.	
	Second mid-exam	43.89	4.523	36.30	3.980	1.264
Learning Attitude	Cognitive	3.68	.156	3.45	.144	1.095
	Emotion	4.43	.140	3.98	.140	2.233*
	Behavior	4.05	.147	3.49	.095	3.324**
Learning Attitude(average)		4.05	.130	6.64	.086	2.682*
Self-Efficacy	Successful experience	4.31	.152	3.60	.134	3.499**
	Active learning	3.44	.176	3.20	.183	0.959
	Good physical and mental state	3.78	.144	3.38	.114	2.213*
Self-Efficacy(average)		3.84	.121	3.39	.105	2.822**
Learning Strategies	Scheduling	3.39	.204	2.98	.164	1.593
	Interpersonal help	3.97	.187	3.53	.117	2.066*
	Teaching and learning	4.07	.144	3.53	.095	3.195**
Learning Strategies(average)		3.81	.122	3.34	.090	3.123**
Learning Achievement	Final exam grade	67.95	4.135	53.20	4.472	2.415*
	Semester grade	72.63	2.902	65.05	3.241	1.737
Learning Achievement(average)		70.29	3.392	59.13	3.811	2.180*

*$p < 0.05$;**$p < 0.01$.

The two groups showed significant differences in learning attitude, self-efficacy, learning strategies and learning achievements. The statistic t-values were 2.682 ($p < 0.05$), 2.822 ($p < 0.01$), 3.123 ($p < 0.05$) respectively, which showed that the experimental group had better learning attitude, higher self-efficacy, better learning strategies and better academic achievement.

4.2 Structural Equation Model Analysis

The Partial Least Squares (PLS) analysis was performed by using SmartPLS software. Maximum iterations were performed 300 times [30]. The final PLS structural equation model was shown in Figure 3.

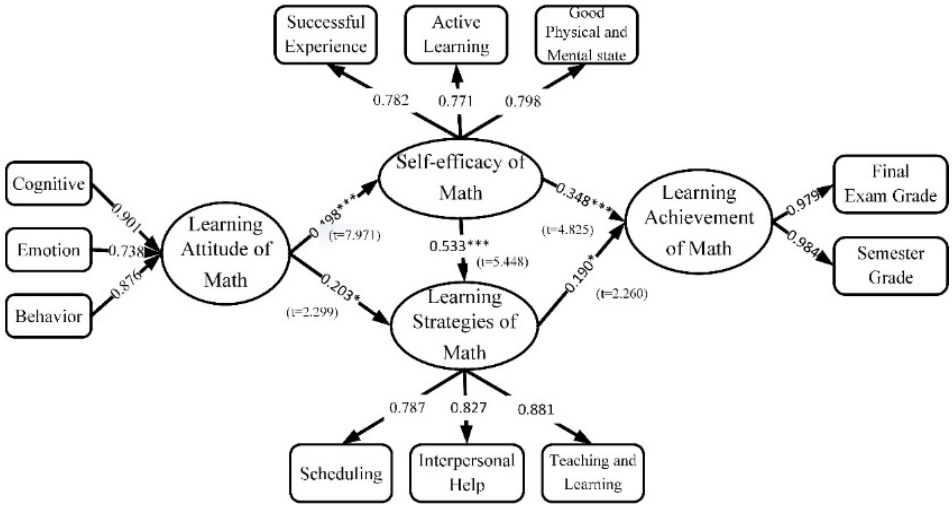

Figure 3. Structural equation model

4.2.1 Measurement Model

In terms of measurement model, three indicators were taken into consideration: factor loadings must be greater than 0.7, composite reliability (CR) must be greater than 0.7 and average variance extraction (AVE) must be greater than 0.5 [31-33].

The factor loadings ranged from 0.750 to 0.983 and were all greater than 0.7 (Table 2). Measurement indicators were with good reliability. The composite reliability (CR) ranged from 0.820 to 0.981 with an internal consistency; the average variance extraction (AVE) ranged from 0.603 to 0.963 and greater than 0.5 for all the constructs, except that the Cronbach's α of self-efficacy was less than 0.7, but was also close to 0.7. Due to the factor loadings, the composite reliability (CR) and the average variance extraction (AVE) of three indicators were in line with standards.

Table 2. Analysis of measurement model

Constructs	Variables	Factor loading	t-value	Cronbach's α	CR	AVE
Learning Attitude	Cognitive	0.897	60.095***	0.873	0.922	0.797
	Emotion	0.907	55.386***			
	Behavior	0.874	60.095***			
Self-efficacy	Successful experience	0.799	26.906***	0.670	0.820	0.603
	Active learning	0.750	21.382***			
	Good physical and mental state	0.779	21.104***			
Learning Strategies	Scheduling	0.785	24.465***	0.775	0.970	0.690
	Interpersonal help	0.824	55.337***			
	Teaching learning	0.929	34.134***			
Learning Achievement	Final exam grade	0.979	306.887***	0.962	0.981	0.963
	Semester grade	0.983	548.999***			

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Except the square root of AVE on self-efficacy construct is not greater than its horizontal and vertical correlation coefficient values, the AVE values of the other constructs conformed to this criterion (Table 3).

Table 3. Discriminant validity: Square root of AVEs and correlation matrix.

	Learning attitude	Self-efficacy	Learning strategies	Learning achievement
Learning attitude	0.797			
Self-efficacy	0.498	0.603		
Learning strategies	0.469	0.634	0.690	
Learning achievement	0.339	0.449	0.411	0.963

Note. The diagonal line of correlation matrix represents the square root of AVE.

Henseler et al. [34] proposed a new Heterotrait-Monotrait (HTMT) method to assess the new criterion of discriminant validity. All of the HTMT inference values were not greater than 1 and showed good discriminant validity. Therefore, HTMT inference was the most relaxed evaluation criteria, HTMT0.9 was a moderate evaluation criteria, HTMT0.85 was the most strict evaluation criteria. It could be seen from Table 4 that the HTMT values of all the constructs were neither greater than 1 nor less than 0.9 and even very close to 0.85, indicating that the discriminant validity was good and met the moderate evaluation criteria.

Table 4. The HTMT analysis result of discriminant validity

	Learning attitude	Self-efficacy	Learning strategies	Learning achievement
Learning attitude				
Self-efficacy	0.642			
Learning strategies	0.562	0.879		
Learning achievement	0.381	0.582	0.470	

4.2.2 Structural Model

A summary of results and hypotheses outcome could be found in Table 5. The results showed that the learning attitude had a positive and significant effect on self-efficacy and learning strategies. In addition, the self-efficacy had a significant positive effect on learning strategies and learning achievement. Moreover, the learning strategies had a significant positive effect on learning achievement. Thus Hypotheses 1-5 were supported.

Table 5. Result of the path coefficient and t-value

Hypothesis	Path	Coefficient	t-value	Hypotheses supported
H1	Learning attitude→Self-efficacy	0.498	7.971***	Supported
H2	Learning attitude→Learning strategies	0.203	2.299*	Supported
H3	Self-efficacy → Learning strategies	0.533	5.448***	Supported
H4	Self-efficacy →Learning achievement	0.348	4.825***	Supported
H5	Learning strategies → Learning achievement	0.190	2.260*	Supported

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

4.3 Cluster Analysis

The researcher used non-hierarchical K-means cluster analysis to understand student's behavioral characteristics.

4.3.1 The Result of Cluster Analysis

According to the observations, the clusters classified as cluster I has 97 persons (34.5%), cluster II has 50 persons (17.8%), cluster III has 71 persons (25.3%), and cluster IV has 63 persons (22.4%).

Using One-way ANOVA analysis, the researcher obtained the average of the four clusters at each facet. Then, Scheffe's Test was used to find out the characteristics of each cluster's facets, and each cluster was named accordingly.

Table 6 showed that the participants in cluster I had the highest scores on each facet, except the emotion facet, which ranked second, so cluster I was named as "proactive". The participants in cluster II had the lowest scores on each facet, so cluster II was named as "self-complacency". The participants in cluster III had the highest score on each facet, except the facet of attitude, indicating that they wanted to understand the content of math, but were not using the correct attitude to deal with the difficulties in math. Therefore, cluster III was named as "Insufficient energy". The participants in cluster IV had the lowest score on the facet of emotion, and higher score on the other facets. Attitude is very important in learning math, and the participants in cluster IV also had good learning achievement. If they could have more active emotion on learning math, they would get higher achievement. Thus, cluster IV was named as "smart and naughty".

Table 6. Cluster analysis of observations

Facet name	Cluster I (n=63)	Cluster II (n=97)	Cluster III (n=71)	Cluster IV (n=50)	F value	Scheffe multiple range tests					
						I-II	I-III	I-IV	II-III	II-IV	III-IV
Efficacy and Strategy	3.40	2.78	3.46	3.28	75.808 ***	***	n/a	***	***	***	***
Attitude and state	3.84	2.60	3.05	3.08	80.540 ***	***	***	***	***	***	n/a
Emotion	3.09	3.08	3.82	2.92	85.542 ***	n/a	***	n/a	***	n/a	***
Cluster name	Proactive	Self-complacency	Insufficient energy	Smart naughty							

n/a not significant ; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

4.3.2 The Characteristics of Each Cluster

As Table 7 showed, clusters of "proactive" and "smart naughty" didn't have any difference on the construct of "Self-efficacy" and "Learning performance", but had significant difference on the construct of "Attitude" and "Learning strategy". If the participants in "smart naughty" had the correct attitude, they would have higher learning performance than the participants in "proactive".

Table 7. The analysis of clusters on each construct

construct name	Proactive (n=63)	Self-complacency (n= 90)	Insufficient energy (n=71)	Smart naughty (n=50)	F value	Scheffe multiple range tests					
						I-II	I-III	I-IV	II-III	II-IV	III-IV
Learning Attitude	3.61	2.82	3.30	2.99	71.898***	***	***	***	***	n/a	***
Self-Efficacy	3.54	2.76	3.39	3.54	43.588***	***	n/a	n/a	***	***	n/a
Learning Strategy	3.39	2.70	3.39	3.90	66.028***	***	n/a	***	***	***	***
Learning performance	68.75	42.03	54.37	67.20	21.064***	***	**	n/a	*	***	*

n/a not significant ; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

The cluster of "insufficient energy" was not different from other clusters on the construct of "Self-efficacy", but showed a significant difference from other clusters on the construct of "Learning performance", so the participants in "insufficient energy" didn't have good learning attitude and learning strategies.

The participants in "self-complacency" had the lowest scores on each construct, and the reason might be that they already had frustration and anxiety on learning math since their childhood.

5 Conclusion and Implication

5.1 Conclusion

5.1.1 The Experimental Group and the Control Group in Learning Attitude, Self-efficacy, Learning Strategies and Learning Achievements are Significantly Different

Although the effectiveness of e-learning may be not very effective [35], some studies believe that e-learning can improve the student's achievement [36]. However, in this study, the experimental group performs better in learning attitude, self-efficacy, learning strategies and learning achievement. Therefore, teachers can encourage students to teach the classmates to improve their learning attitude, self-efficacy and learning strategies, so that learning achievements can be naturally improved. Using digital technology can make learning achievements more effective [37-38].

5.1.2 Learning Attitude, Self-efficacy, Learning Strategies and Learning Achievement have Correlations

The overall structural equation model explains a moderate fit, thus the learning attitude, self-efficacy, learning strategies and learning achievements have correlations [19, 23, 39]. Motivation is important in students' learning and performance. Self-efficacy is a significant predictor for student motivation and learning [23, 40]. It is a chain reaction, positive attitudes affect self-efficacy and strategies. Self-efficacy also affects strategies and achievements.

There are a lot of researches between attitude, self-efficacy, strategies and achievement, but most of researches focuses on higher education or primary school [8-10, 20, 28-29, 37]. Only a few researches focused on the high school stage [22, 40-41]. This study undoubtedly adds new information to the research of high school students.

5.1.3 Self-efficacy is a Mediator of Learning Attitude towards Learning Strategies; Learning Strategy is a Mediator of Self-efficacy to Learning Achievement

The variance accounted for (VAF) means that the indirect effect is a percentage of the total effect [42].

The learning attitude has a significant direct effect on learning strategies; meanwhile, learning attitude has significant effects on self-efficacy; self-efficacy has significant effects on learning strategies. The calculated VAF value of self-efficacy was 56.7%, so self-efficacy has partial mediation of learning attitude on learning strategies.

Self-efficacy has a significant direct effect on learning achievement, while self-efficacy has significant effect on learning achievement, and learning strategies has significant effect on learning achievement. The calculated VAF value of learning strategies was 22.5%. Therefore, learning strategies has partial mediation of self-efficacy on learning achievement.

5.2 Implication for Practice

5.2.1 Apply Information Technology to Record the Demonstration Video Can Improve Students' Learning Attitude

Students in the process of explaining the issue or question are familiarizing themselves with the basic concepts and questions repeatedly, and naturally improve their learning attitude. By recording videos, students can also practice their expression skills more courageously and confidently. The videos are also intended for students who wish to watch to learn and enhance their confidence during the process of learning.

Using information technology to achieve the advantages of digital learning and cultivate a more proactive attitude and spirit of learning can enhance students' ability and competitiveness.

5.2.2 Stimulate Students' Learning Attitude Will Improve Their Self-efficacy, Learning Strategies and also Enhance Their Learning Achievement

Learning attitude not only affects self-efficacy and learning strategies, but also affect learning strategies indirectly through self-efficacy. As a teacher, one should pay attention to students' learning attitude and self-efficacy simultaneously. Students should understand that as long as they work harder, they can understand the contents of the course better. When teachers using IT to encourage their students to participate more in digital learning, and thus make students like to discuss relevant topics and topics of the course with their teachers and classmates, students will actively study and discuss with their peers. Therefore, their learning attitude will be enhanced and their feelings of self-efficacy will make their learning strategies and learning achievement better.

5.2.3 There are Different Clusters of Student on Learning Math

According to the cluster analysis, students are divided into four clusters: proactive, self-complacency, insufficient energy, and smart naughty. Each cluster has its own unique characteristics. The participants in "proactive" are very serious in learning attitude and self-efficacy, and also have good learning performance. If they possess learning strategies, they will have better performance.

"Self-complacency" students not only do they not enjoy math, but they are also not self-efficacious due to previous failure of math courses. Thus, such students often experience negative emotions like anger in math classes [22, 40].

The participants in "insufficient energy" didn't have good learning attitude and learning strategies.

The "smart and naughty" participants are very good at self-efficacy and learning strategies. They also have good learning performance. If they can study harder, they will have better performance.

5.3 Limitations

Due to the regional relations of the schools taught by the researchers, and the limited number of students in the course of study, the results of the inference are limited. Future studies can expand on the number of samples and the number of experimental subjects. Future studies can probe into these models in a broader sense and the degree of impact between these factors. In the meantime, other variables that affect learning achievement may also be added in the future to explore the correlation and influence among more constructs.

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