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An Analysis of the 3D Video and Interactive Response Approach Effects on the Science Remedial Teaching for Fourth Grade Underachieving Students

Chin-Cheng Chou
National Taipei University of Education, TAIWAN

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ABSTRACT

Elementary school remedial teaching has been promoted for many years in Taiwan but it has primarily been aimed at Chinese and mathematics with little attention being paid to natural sciences. Due to the current shortage of natural science teachers, along with limitations in school budget and manpower, it is difficult to put natural science remedial teaching into practice in elementary schools. This research attempts to establish a new model of remedial teaching that utilizes remote asynchronous video-based instruction to carry out centralized remedial teaching with 3D television and interactive response system. We focused on fourth graders whose science ranking was at the bottom quarter and examined if their grades have improved. Centralized remedial teaching was implemented once a week during school's noon break and lasted for 40 minutes. The materials used, including the remedial 3D natural science lesson videos and interactive response test questions, were both produced by the university. They were transmitted through the Internet to elementary school teachers who played them on 3D television and students practiced and answered the questions in real time with plickers. Twenty fourth graders from different classes participated in remedial teaching for one semester; the average percentage of test grade ranking in natural science has progressed from 9.19% to 24.12% in their original classes. Previously, the average of T-score in natural science test was 35.80, and after remedial instruction, the T-score average was 42.39. The T-score average improvement is statistically significant ($t=3.34$, $p = .003$). The research revealed that this instructional model can improve learning outcome in natural science for underachieving fourth graders, and through the questionnaire, it was also known that the students liked this remedial teaching approach.

Keywords: 3D video, elementary school science, interactive response system, remedial teaching

Correspondence: Chin-Cheng Chou, Department of Science Education, College of Science, National Taipei University of Education, 134 He-ping E. Rd., Sec. 2. Taipei 10671, Taiwan, R.O.C.
ccchou62@tea.ntue.edu.tw

State of the literature

- Literature analysis finds that most remedial teaching for underachieving students in elementary schools were mainly focused on mother tongue and mathematics.
- Using interactive response system in course is superior to didactic teaching, and it boosts students learning motivation. Nevertheless, there is still little research on natural science remedial teaching for elementary school students.
- 3D video can attract students' attention to watch the film, and it helps in terms of devotion to learning.

Contribution of this paper to the literature

- Implementing elementary level natural science remedial teaching with the aid of 3D video and plickers can significantly improve underachieving students' grades.
- To implement elementary school natural science remedial teaching on underachieving students, provided that proper instructional resource is available, non-natural science teacher can also assist in natural science remedial teaching to a degree.

INTRODUCTION

Around 40 years ago, people started to pay attention to the research of remedial teaching (Cashdan & Pumfrey, 1969). The No Child Left Behind Act of the US was aimed to shrink the difference of learning attainment for underprivileged K-12 students. One of its goals is to improve students' English and mathematics grades, and this has also influenced other countries around the world in terms of the attention they paid on laggard students (No Child Left Behind [NCLB], 2002). In Taiwan, the Ministry of Education has advanced the implementation scheme of remedial teaching for middle and elementary school students since 2006, and it is called "After School Alternative Program." Main subjects of the program are Chinese and mathematics, and the main administrators of remedial teaching are school teachers (Tsai, 2014).

Within the current social context, citizens should possess basic science literacy. Hence, underachieving students will still need natural science remedial teaching and hold basic scientific literacy. Recently, there are many remedial teaching research that focused on science and mathematics, such as mathematics lesson for middle school (Wang, 2011), mathematics lesson for elementary school (Wang, 2014), remedial teaching strategy for developing the concept related to current model (Stocklmayer & Treagust, 1996), or development of physics remedial teaching strategy for ninth grader (Idar & Ganiel, 1985). However, there are still only a few natural science remedial teaching research for elementary school. One of the important goals in pedagogical research is how to help underachieving students to improve their study outcome (Lin et al., 2013).

In the case of Taiwan, elementary schools have not been actively pushing for science remedial teaching that target underachieving students. The main reasons behind this are time, funding, and insufficient natural science teachers. As such, the current research will start with the following four directions to construct a feasible instructional model to solve this problem: 1. To have the university provide natural science remedial teaching videos to be shown by non-natural science teachers; 2. To implement centralized remedial teaching after school; 3. To raise student motivation by showing 3D videos; and 4. To increase instructional interactivity through the use of instant response system. It is aimed that underachieving students' learning and motivation could be raised through the above methods. Therefore, the research goal of the current study is to design a natural science remedial teaching model that is suited to elementary schools; the research question as such is whether remedial teaching models designed in such a way can significantly improve underachieving students' learning based on pre- and post-tests.

THEORETICAL BACKGROUND

Remedial teaching

McLaughlin & Vacha (1992) pointed out that the common characteristics of at-risk student are as follow: 1. Poor test answering skills, 2. Low attainment, 3. Test performance under average, 4. Assignment not submitted, 5. Lack of the elder's oversight and encouragement on scholastic achievement, 6. Lack of awareness on the correlation between scholastic achievement and career worlds. In general science remedial teaching lessons, we would mainly help students comprehend the content of science lesson via educational materials design and boost their learning motivations and interests.

Case (1993) stated that remedial instruction helps students overcome learning difficulties, and this learning theory is grown from the cognitive revolution. Immediate and adaptive remedial instruction system helps student's learning, and the greatest advantage is that it provides immediate feedbacks for the errors (Hsiao et al., 2016). Through the quasi-experimental research and design, Dai and Huang (2015) applied three different types of teaching model of remedial teaching on vocational high school students with bad mathematics grades. It has been found that these three methods can improve students' mathematics grades; e-learning instruction model helps the most, followed by blended learning model, and the least helpful is the traditional instruction model.

Although many research studies have pointed out numerous advantages of computerized adaptive remedial instruction system, its instructional usage was still limited. This is because it has been observed that there were a limited number of computer laboratories in actual locations of instruction. Consequently, natural science teaching could not fit into computer laboratory's schedule. To be able to execute remedial teaching in the general class setting is thus the aspect which this research desires to inquire.

3D video instruction

There are many video-based learning-related research studies. For example, Giannakos (2013) analyzed major educational technology journals from 2000 to 2012 and found 166 articles that were related to video-based learning. The author found that this field has grown rapidly since 2007, but only 7.38% of the studies targeted primary education. The review's statistics on the technology of the video showed that 68.87% of the papers dealt with asynchronous systems, 61.45% non-interactive systems, indicating that these types of research is more common. Oropeza, Sanchez, and Villagomez (2015) found that using stereoscopic 3D video in university orthodonitcs courses could yield better instructional results than traditional method that used projection of slides. Regarding teaching DNA structure using stereoscopic 3D in high school biology, Ferdig, Blank, Kratcoski, and Clements (2015) found that with 3D videos, student assessment results were significantly higher than those students who did not use 3D videos.

3D virtual technology provides the user a real visual experience, and there are many pedagogical and learning research in recent years (Cho, Yim, & Paik, 2015; Chow, 2016; Yilmaz, Baydas, Karakus, & Goktas, 2015). 3D reality can make users more involved in the interaction, and gender will not influence how involved students are toward the interactivity but experience and spatial ability would (Yilmaz et al., 2015).

Kim (2006) indicates that the effect of using 3D virtual reality to teach fifth graders Plate Tectonics is superior to 2D instruction. Although 3D seems good for learning, there are some research in opposition to it. Richards and Taylor (2015) administered a two-year research which focused on sophomores learning a biological theory called Marginal Value Theorem, and it was found that 3D teaching is not better than 2D. The reason is inferred to be that the learners have heavier cognitive loads through 3D when studying.

Lin et al. (2013) revealed that sixth graders' mathematics can be made more sophisticated by using video-based remedial instruction, but game-based remedial instruction can do even better. However, the student sample of this research was not underachieving students but students in general.

Using 3D video can potentially boost students' learning motivation, but there are still very few research studies on 3D video-based teaching and remedial teaching. This research will inquire the learning effects of remedial teaching with 3D videos.

Interactive Response System - plickers

Real time interactive device are called many different names in instruction related literature; audience response system is the most frequently used (Hunsu, Adesope, & Bayly, 2016; Wenz, Zupanic, Klosa, Schneider, & Karsten, 2014), followed by electronic voting system (Cubric & Jefferies, 2015; Draper & Brown, 2004), electronic response system (Donovan, 2007; Ghosh & Renna, 2009), personal response system (Lin et al., 2013; Yeh & Tao, 2013), student response system (Hooker, Denker, Summers, & Parker, 2016; Jones, Antonenko, & Greenwood, 2012), clickers (Hwang, Wong, Lam, & Lam, 2015; King, 2011), classroom response system (Chien, Lee, Li, & Chang, 2015; Richardson, Dunn, McDonald, & Oprescu, 2015), interactive response system (Y. Kim et al., 2015; Slain, Abate, Hodges, Stamatakis, & Wolak, 2004), and instant response system (Chien, Chang, & Chang, 2016; Chien et al., 2015).

Chien et al. (2016) conducted a meta-analysis on Clicker-integrated instruction related research papers, and it was discovered that Clicker-integrated instruction is superior to conventional lectures. Hooker et al. (2016) analyzed Clicker benefits and found the following: 1. Students can know other peer's thinking, 2. Students can examine if they understand the contents taught, 3. Anonymity could prevent students from feeling awkward when answering, 4. It can let students know where the problem is, 5. Teachers can adjust their teaching if they find students were having difficulties, 6. It can help students know how they are doing, 7. It can make students more eager to participate in learning, and 8. Students can receive learning feedback.

Generally, developing Interactive Response System is complicated and expensive, but recently, some free Interactive Response Systems have emerged. Related educational research have also been produced by scholars, such as Kahoot! (Fotaris, Mastoras, Leinfellner, & Rosunally, 2016; A. I. Wang, 2015) and Socrative (Blackburn, 2015; Guerrero, Jaume, Juiz, & Lera, 2016). Plickers is a convenient tool that lets teachers collect real-time formative assessment of four choice test items or true-false test item data without the need for student devices. Teacher has one computer and one smart mobile device with Internet access can be carried out assessment (Plickers, 2016).

Chien et al. (2015) find that using real-time response teaching is fun for both teachers and students. This is because when teachers conduct Clicker-integrated instruction, they will be able to provide students with real-time feedback and boost students' motivation in participating. Nevertheless, the subjects analysized in that research were undergradate or graduate students, and it was suggested that research with elementary, middle, and high school students are still needed for further verifcation.

For underachieving students, there are very few pedagogical papers that used plickers in their research. This research aims to understand the impact of interactive response system when used in elementary school students' remedial teaching.The current research attempted to explore remedial teaching that combined 3D instructional video and interactive response system, to see if it could improve fourth grade underachieving students' natural science grades.

METHODOLOGY

Sample of Research

The participants of the current research were fourth graders from an elementary school in Taichung, Taiwan. The school principal gave the permission to conduct this remedial teaching course in this school. There were a total of 278 students in the 11 fourth grade classes of this school. Based on the Ministry of Education (2012) norm, the so-called underachieving students were "students whose grades were placed at the bottom 25% of each subject class in urban areas, the bottom 35% in rural areas." Therefore, we selected students whose grades from the previous semester fall at the bottom 25% of their respective classes, allowing two volunteer students from each class to participate. Only students whose parents had signed the consent form could participate in this remedial teaching course. Consequently, there were a total of 22 students who participated in this remedial teaching; two students quit midway through the research project due to personal reasons. Students who participated in remedial teaching were the experimental group, numbered at 20 students, out of which six were boys and 14 were girls. The 258 students who did not participate in the remedial teaching were the control group. In centralized remedial teaching design format, the 20 students who participated underwent 40 minutes of remedial teaching every Thursday from 12:40 pm to 13:20. The reason why the current research did not invite a science teacher to assist us was that we wanted to know, given the current shortage of elementary natural science teachers, if it is feasible to have non-science teachers assist in natural science remedial teaching.

Instrument and Procedures

Every week before the course starts, researchers would edit and produce an approximately 30-minute long instructional video, which would include in-class real time test questions that would be sent to the elementary school teacher via the Internet. The content of the instructional video was edited by the author of this paper, this includes the 3D videos that contained answers to questions students raised in the week before, the author demonstrated 3D experiment video, related 2D news videos found online, and selected textbook vendor provided 2D instructional videos. The editing of the video followed the "raise questions – watch the content" formula. In other words, a question that students often get wrong would be raised in the video, followed by a few seconds for students to answer and show their own answers, such that student motivation could be raised. A follow-up video would then be shown immediately after to help students focus on the center point of the video. After the half-hour long video has ended, a 10-minute long plickers activity be implemented.

Instructions of this semester has four themes: "Knowing Time – The Measurement of Time", "The Movement of Water – Capillarity and the Law of Communicating Vessels", "The Insect World – Knowing the Life of Insects", and "Wondrous Water – The Three States of Water and Buoyancy". The school teacher executing remedial teaching was not a natural science teacher. Her primary responsibility was to assist in the showing of the videos, let students answer in real time with plickers, and gather student feedback at the end of the class. The current research purchased and placed a 55-inch 3D television and 28 pairs of stereoscopic 3D glasses in the elementary classroom for video showing (**Figure 1**). 3D experimental videos would be shown to supplement science lessons when there were suitable experiment topics; plickers would also be used for instructional interactive tests.

Plickers is currently a free software. Anyone can use it provided they register at the website. Each student would hold a square card, each having a different pattern. Each card would have four directions, each direction representing A, B, C, and D (**Figure 2**). After the teacher has revealed the question, it would be projected to the screen by the projector that is connected to the computer. After reading the question, each student would hold up their answering card. The teacher would scan the class with his/her cell phone camera, and after a few seconds, all of the students' answers would be instantly tallied (**Figure 3**). The teacher then displayed the tallied result of the class's answers through the projector (**Figure 4**). The teacher can also show how each of the students answered and if they were correct.

Figure 1. Students with wearing the 3D glasses and watching the 3D video

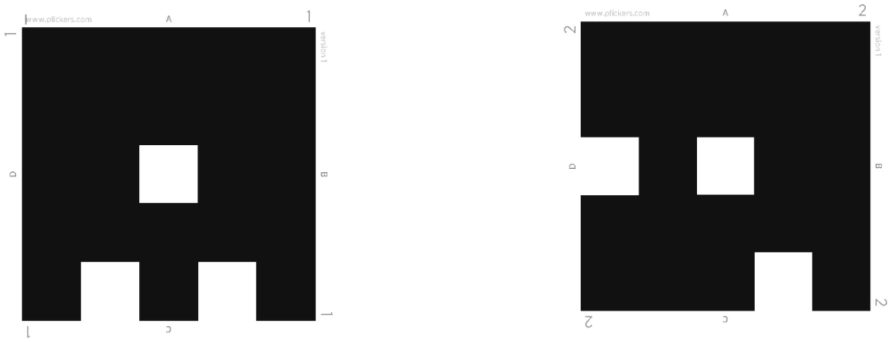

Figure 2. The sample of Plickers' cards

Figure 3. The screenshot from teacher's smartphone in operating plickers

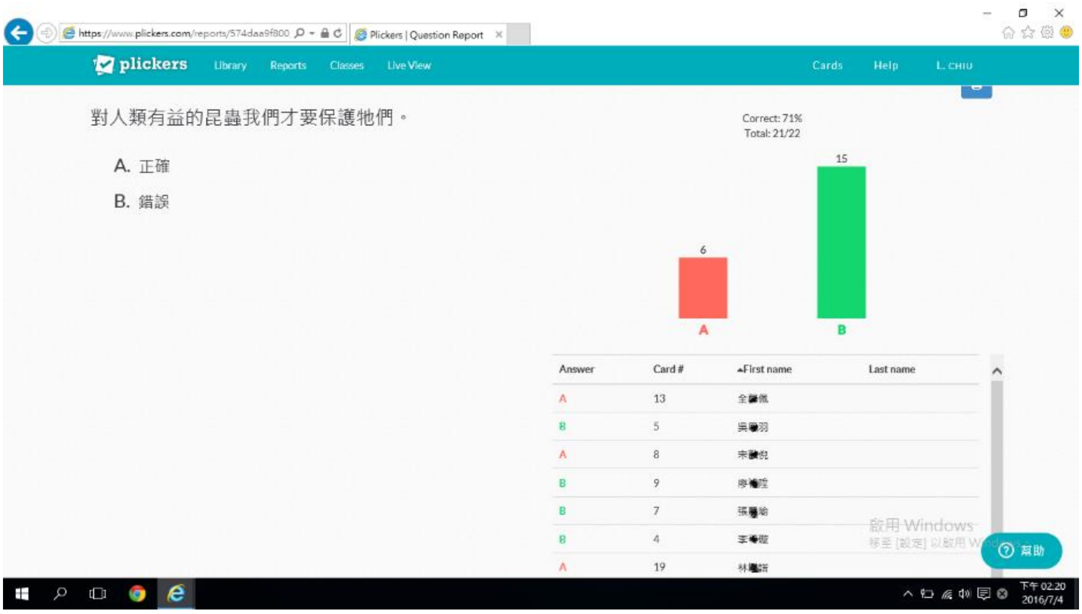

Figure 4. The computer can display students' answering statistics

Data analysis

Data is based on students' midterm and final exam grades of the previous semester, and the midterm and final exam grades from the semester during which the student participated in the remedial teaching course. The current research utilized descriptive and inferential statistics, including means, standard deviations, independent samples t-test, and paired-sample t-test. Data analytical tool was SPSS 20.0.

RESULTS

Since the 20 students of the course came from 11 different classes, and these classes did not have the same natural science teacher, comparison of student grades was impossible. Consequently, each student's grade was converted into T-scores within their respective class for statistical tests. The average natural science test grade T-score before participating in the natural science remedial teaching course was 35.80. After the remedial course, the T-score average was 42.39 (**Table 1**). The improvement was statistically significant ($t=3.34$, $p=.003<.01$). Before the course, the average ranking percentage of the 20 students in their respective classes was 9.19%. After the course, the average increased to 24.12%. Before the remedial teaching, difference between the experimental and control groups was statistically significant ($t=7.392$, $p<.001$), with the control group performing better than the experimental group. After the remedial teaching, difference between the experimental and control groups was statistically significant ($t=3.686$, $p<.001$), with the control group performing better than the experimental group (**Table 2**).

Table 1. Student Assessment Grade Statistics

remedial teaching		Fourth grade First semester average exam T-score		Fourth grade second semester midterm exam T-score		Fourth grade second semester final term exam T-score		Fourth grade second semester average exam T-score	
	n	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
nonparticipants	258	51.13	9.05	50.50	9.71	50.63	9.69	50.63	9.64
participants	20	35.80	7.05	43.17	9.35	43.58	10.41	42.39	9.58
Total	278	50.03	9.74	49.97	9.83	50.13	9.87	50.04	9.84

Table 2. Before and after semester grade improvement T test

remedial teaching	4^{th} Grade Semester Score	Averages' Difference	t	p (two-tailed)
nonparticipants	2^{nd} Semester Avg – 1^{st} Semester Avg	-0.49	-1.34	.181
participants	2^{nd} Semester Avg. – 1^{st} Semester Avg.	6.58	3.34	.003

Further analysis of the experimental group's T-score improvement showed that 15 students improved and five students remained unchanged. Yet when the score was compared to their respective original class ranking, 14 improved, two unchanged, and four students' ranking lowered. Nine of the students' ranking were higher than the 25% mark and thus would not need to attend the remedial teaching course the following semester. If midterm and final exam scores were analyzed separately, the second semester fourth grade midterm average T-score was 43.17, final exam average T-score was 43.58; there is no statistically significant difference between the two (t=1.70, p=.867 > .05), indicating that student grade improvement was steady. However, the final exam score was still slightly better than the midterm score. The reason behind the fact that the final exam grade ranking average was slightly better than that of the midterm was that the longer students participated in the course, the more likely the student were used to this kind of remedial teaching.

By gathering students' thoughts on the utilization of plickers for the remedial course assessment, it was found that students liked this kind of assessment method. Since assessment result and answers would appear on the screen instantly, students would know the number of fellow students who chose the same answer as he/she did. Although the plickers system can display whether the student answered correctly or incorrectly for each student, the researchers of the study still requested the homeroom teacher to not display the accuracy of individual students' answers. This is because these students are underachieving students and the researchers were concerned that presenting the accuracy of individual student's answers could lead to undue stress among students who did not answer correctly. Part of students' thoughts are as follow:

S08: Because this kind of assessment (plickers), not only could it help us review, I also think it is very interesting and fun, it can also let us know things that we don't understand.

S09: Because we can assess ourselves, and also know the things that we don't quite understand.

S19: It's fun, very interactive.

The homeroom teacher who assisted us in the course stated:

> As an assessment approach, plickers can attract student attention, increase motivation, students would look forward to "play" with this assessment system. From the viewpoint of a teacher, if there were no equipment readily available, existing question sets, it would be an added burden for teachers. But when assessing with this system, it must be accompanied by teacher's verbal explanations, to let students understand the reasons behind the right and wrong of their answers clearly and in detail. Students who got it wrong must know why their answers were correct or wrong, only then could his/her metacognitive ability be enhanced.

After participating in the course for the entire semester, students provided the following feedback in the End of Semester Feedback Survey on the remedial teaching of the semester:

S01: It was really fun, interesting, made me feel happy, learning common sense, knowledge in our daily lives, very satisfied.

S03: I am really happy that I can attend this course, the course is very diverse, we could watch 3D videos, and it allowed me to understand what was taught in school.

S17: You gave me a lot of natural phenomenon, I really want to come again because it was just so much fun, the best was being able to answer questions.

S19: I would like to thank all the teachers for letting us have this great course and activity, letting us aim at science and not just have science lessons, and having this kind (plickers) of review activity.

Instructional video and questions were edited and compiled by the researcher. It took some time to find new clips and shoot scientific experiment demonstrations 3D videos that are appropriate for elementary school students. However, the school teacher who assisted us in the course said that most students would talk amongst themselves while watching the instructional video, but would quiet down and pay attention on their own when the researcher filmed scientific experiment demonstration and extracurricular videos (such as news clips) were shown. It was found that it was not that underachieving students did not want to learn, but that there was a lack of suitable materials that could sufficiently raise their level of interest in learning. Through grasping this point when designing instructional material for underachieving students, natural science teachers could enhance students' motivation in learning.

DISCUSSION AND CONCLUSIONS

Based on the results of the current research, it was found that remedial teaching strategy that encompasses 3D video and interactive response system can improve the grades of underachieving fourth grade science students. This is consistent with study results that showed 3D video being able to raise student learning results on specific topics (Ferdig et al., 2015; Oropeza et al., 2015) and IRS increasing student learning result and motivation (Chien et al. ,2015).

Improvement in science grades among students who participated in remedial teaching for an entire semester was statistically significant. Through paper-based questionnaire, it was also found that remedial teaching strategy encompassing 3D video and interactive response system can enhance students' learning motivation. Remedial teaching of the current study adopted the format of centralized remedial courses, but also integrated approaches from existing natural science lessons. Whether existing natural science lessons could also improve underachieving students' grades with 3D instructional video and interactive response system remains to be explored. The cost of utilizing plickers as the interactive response system equipment was not high. Yet, 3D televisions are still uncommon in most schools, limiting future promotions of such instruction. Further research will be needed as it is unclear how replacing 3D video with that of 2D would lower student motivation and performance improvement. Moreover, gender-based analysis on improvements was not feasible in the current study due to the imbalanced gender ratio of participants. Lastly, there was also very limited number of studies on the long term impact of watching 3D television on student vision and learning; this will be another topic that would warrant further long term studies. In future natural science remedial teaching, given limited manpower and provided with appropriate science remedial teaching material, non-science teachers could also implement such remedial teaching. Moreover, by adopting remedial teaching that integrated digitized instructional video and interactive response system will also make putting such instructional resource available online possible, providing opportunities of expansion to other elementary schools.

Utilizing remote asynchronous video-based instruction to carry out centralized remedial teaching that had executed three semesters, we found that this instructional model could improve learning outcome in natural science for underachieving fourth graders. For this semester, we added the plickers tool to increase the interactive with the underachieving students. In the three semesters preceding the current study, 3D videos were also used in remedial teaching for fourth graders, student performance had also attained statistical significance. As such, plickers was added in this semester. Yet, since student sample and the content taught for different semesters also differed, it is difficult to provide an objective comparison of student improvements from different semesters and find out if there is any difference between 3D video and 3D video plus plickers. Consequently, a research with two experimental groups could be conducted in the future. Nevertheless, based on student questionnaire, it was revealed that student think that having plickers has made the course more fun. This is something that was absent from previous semesters where only 3D videos were used. Raising learning results of underachieving students was difficult to begin with, that is why the current research has adopted blended learning, to combine multiple effective instructional modalities to enhance student learning. For example, Alonso, Manrique, Martinez, and Vines (2011) adopted blended learning for underachieving students in a university software engineering related course. Yet, the current study has also added plickers, and students has responded in the questionnaire that it is more interactive and fun. School teachers also observed that students behaved like they were playing games when they used plickers to answer questions and were more willing to be engaged.

The limitations of the research were shown below: 1. Random sampling was impossible since experiment samples were drawn from the bottom 25% of fourth graders with parental consent from one particular school. 2. Since there were only a limited number of participating students each semester, and the time allowed by school for remedial teaching was also limited, it was not possible to have two experimental groups with two different experimental designs proceed simultaneously in the same semester (e.g. to have a group of students with 3D videos and the other group with 3D videos and plickers). This prevented the current study from analyzing more variables and their interactions. 3. It remains unclear if this instructional model is also suited for non-underachieving students. Although there are still many problems that the current research need to overcome, the instructional model adopted can indeed not only help underachieving students improve significantly, it could also be helpful in practice, and promoted to other schools.

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