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On the Clickers Use in Education

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Abstract

Since the birth of clickers at Pennsylvania State University, there have been numerous arguments on its effectiveness. This study, aiming to review the use of clickers in education, examined literature over around a decade on the use of clickers, involving benefits and defects of use of clickers, peer discussion, use of clickers in learning, teaching and problem solving, the effectiveness of the use of clickers among non-students. Besides, relationships between lecturing and learning aided with clickers, and current developments in the use of clickers were also reviewed and discussed. It was concluded that clickers, as one form of modern technology, had gained growing popularity due to their advantages, such as peer discussion, anonymity and instant feedback although disputes still remained. More studies on clickers and other new technologies were still needed to further push forward levels of education. Cross-disciplinary cooperation between computers, education and psychology may be needed to design more advanced educational technologies.

Subject Areas

Educational Technology

Keywords

Clickers, Learning and Teaching, Peer Discussion, Problem Solving

1. Introduction

Technologies could be integrated into learning and teaching to improve effectiveness. Clickers are a kind of technology easily applied in education (Bruff, 2009) [1]. Clickers are also called a Classroom Communication System, Student Response System, or Audience Response Technology. Clickers-aided education refers to inquiry-based pedagogy coupled with a clicker technology system, a computer technology that enables instructors to raise questions and has students respond using hand-held devices (clickers), through which the questions and

answers summarizing student responses can be displayed simultaneously on the multimedia projector (Figure 1).

Although the use of clickers has been catching growing attention in the field of education, there are, admittedly, still some controversial issues regarding clickers-assisted learning and teaching. Examples are the effectiveness of clickers use in teaching and learning (Chen *et al.*, 2010) [2], in large-scale and small-scale classes, and among non-students. With the controversial issues, learners and teachers tend to feel puzzled to determine whether to use clickers in education and which pedagogy should be adopted when clickers were in use. It is therefore important to review this literature in order to address the issues in question.

Why have some arguments gone against clickers? How can we explore and overcome the obstacles on the way to education assisted with clickers? How can we extend the support factors to facilitate the use of clickers? The purpose of this study was to identify obstacles and support factors that influence the use of clickers in learning and teaching in the education sector.

2. Material and Methods

This study was conducted in order to extensively examine past literature on the advantages and problems of clicker use. The criteria of selecting previous studies as the pillar of this study were:

1) The paper included had to be published in a peer-reviewed journal in edited collections;

2) Master's or doctoral dissertations and short reports were excluded;

3) The paper had to focus explicitly or implicitly on blended learning;

4) The paper had to provide a sufficient description of data and data analysis from which the results were concluded.

Based on these criteria, 34 publications (available upon request) were found to be suitable for inclusion. The review study was mainly based on the findings of these studies.

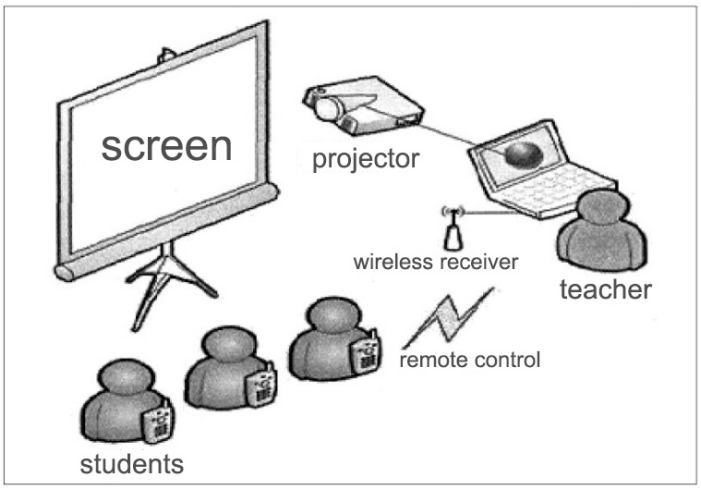

Figure 1. Clickers-aided education.

Once the nature of the sample was established, the publications were then further categorized by obstacles and support factors that arose from reading the corpus of papers. The focus questions to identify the obstacles and support factors were as follows:

1) Is the use of clickers effective in teaching and learning?

2) What is the relationship between lecturing and learning aided with clickers?

3) Can the use of clickers promote peer discussion?

4) Can the use of clickers benefit learning and teaching in large-scale and small-scale classes?

5) Can the use of clickers promote peer discussion in problem-solving?

6) Can clickers be used among non-students?

7) What is the role of clickers in knowledge retention?

8) What are current developments in clicker use?

The cited studies were explored to discuss the key themes in the following sections. The prototype of the clicker device was created and developed by Carpenter (1950: p. 33 [3]; 1950: p. 20 [4]) at Pennsylvania State University. Forty-four years later, "Peer Instruction" gave rise to the rapid development of clickers at numerous educational institutes in Europe and North America, followed by prospering studies on clickers.

3. Results

Until now, there have been numerous arguments both for and against the use of clickers. The following sections will elaborate on them.

3.1. Use of Clickers in Teaching and Learning

Findings of use of clickers in literature were not in agreement although overall they were supportive of clickers. Whether the use of clickers has been explored maturely or systematically cannot outweigh the research into the effectiveness of clickers use in teaching and learning.

It was considered as an effective means to engage students and stimulate their interest so that interactive communication among learners could be facilitated via clickers in the classroom (Chen *et al.*, 2010) [2]. Through case studies, it was also proved that using "clickers cases" online was an effective strategy for engaging undergraduate students in physiology. However, the study of Chen *et al.* (2010) [2] was limited to a single engineering course, and the small sample size was not convincing enough.

Some studies revealed that the use of clickers showed large gains in learning outcomes (e.g., Beatty *et al.*, 2006 [5]; Caldwell, 2007 [6]). The conclusion of the study conducted by Caldwell (2007) was somewhat over-generalized since the author only conducted the study on an introductory biology course [6]. It is unconvincing to conclude the effectiveness of clickers in all courses through its success in only a biology course. It is also hasty to conclude that clickers could be incorporated into a standard lecture course to increase interaction between stu-

dents and instructor or used as part of a more radical change in teaching style. Caldwell's study (2007) cited much work of his own observation, which might be difficult to avoid personal bias [6]. The effectiveness of clickers needs to extend the research scope to engineering, science, humanities and arts.

Mayer and the colleagues also found large gains in academic results. Nevertheless, limitations such as researcher bias, novelty, and confusion were not excluded. One of the authors (Mayer) acted as the instructor for the course, which might have unconsciously changed his teaching style in subtle ways that would support the main prediction. The use of clicker technology was still a relatively new phenomenon, which might have appeared novel to students. Three treatments that differed along several dimensions might have also caused confusion. The limitations alerted us that the effectiveness of clickers might be further investigated although it was proved effective in many situations.

In addition, some studies found merely moderate gains (e.g., Chen *et al.*, 2010) [2] and others claimed no gains (Caldwell, 2007) [6]. Lasry's study collected data from a single final examination, which did not provide convincing data. Several times' quizzes combined together might provide more convincing data. Furthermore, there were 10 to 12 instructors marking the final exams and no special training was mentioned. Biases among these over ten instructors were unavoidable, possibly causing the reliability problem in findings.

Despite the fact that disagreements still exist in the effectiveness of clickers in education, numerous studies have claimed the benefits of clickers. Advantages of clickers beyond academia were reported (Miller *et al.*, 2012) [7]. Without quantitative data support, this conclusion seemed fragile. However, this study opened a new window to the use of clickers beyond school settings, which would possibly promote research on the use of clickers in various environments.

Several authors maintained that the majority of clicker data collected to date was anecdotal or qualitative (Schackow *et al.*, 2004) [8]. An analysis of data collection techniques used partially supported this claim. Both qualitative and quantitative data were needed to fully explore the influence of clickers, so integration of methods might be a desirable direction for future research efforts (Kay and LeSage, 2009) [9].

Many studies explored the effects of clickers on various aspects of students' classroom experiences. The educational benefits of clickers could be summarized in terms of both teaching and learning. Clickers realized teachers' effective teaching through timely feedback and evaluation since students could poll without their identities being revealed (e.g., peer discussion). Teachers could assess students' understanding of the contents, and students could weigh their own conceptual understanding. The profound impact on student learning was well demonstrated in many studies on clickers. Clickers could have a positive influence on students' emotions, motivation, and cognition in the classroom.

Clickers could stimulate students to participate in learning activities in the classroom and impact learning and instruction by improving students' percep-

tions (Crouch and Mazur, 2001) [10]. A growing number of studies on clickers revealed many effects of clickers in the classroom throughout all disciplines. Examples were increasing attention, attendance, interaction, teamwork motivation, positive emotion and participation, engagement and meta-cognition and learning (Campbell and Mayer, 2009) [11].

3.2. The Relationships between Lecturing and Learning

The relationships between instructors' lecturing and students' learning were not adequately explored in studies on clickers. Studies on clickers tended to focus on the effects of the use of clickers in education by comparing clickers with traditional lectures rather than identifying the interaction among instructors' teaching strategies, clickers, and student learning styles. However, the study only covered the literature before 2006 without convincing empirical study. The study was conducted through a survey where only elementary and secondary educators and students were included, excluding participants from higher education.

An important issue in the literature on clickers was the relationship between instructors' use of clickers (*i.e.*, for formative or summative assessment) and how students perceived its use in the classroom. Most studies compared the effects of using clickers on various aspects of student learning with the non-use of clickers in the teaching process (Campbell and Mayer, 2009) [11], thereby attempting to reveal the educational benefits of the use of clickers. Only a few studies identified the relationship between instructors' use of clickers for formative or summative assessment and students' experiences. For example, James found no significant differences between students' learning when clickers were coupled with formative compared with summative assessment for introductory physics courses. However, it was argued that student groups using clickers for formative purposes participated more and were more engaged in peer discussion than their counterparts aiming at summative purposes.

Han and Finkelstein responded to some of the criticism of clickers studies by exploring students' perceptions of clickers and also investigated the relationship between instructors' pedagogical development aided with the educational technology, their use of technology, and students' perceptions of the impact of clickers on their learning, which was considered a missing link in the technology evaluation literature in higher education. It was concluded that when using clickers in the classroom, students perceived clickers as useful for engagement and learning, instructors' longer-term clickers development had more impact on student perceptions of clickers' use for their engagement, and formative feedback with clickers had more influence than summative feedback with clickers on students' perceptions of clickers use.

3.3. Peer Discussion

Clickers and the designed questions tended to be integrated into peer discussion, which was a key assistant tool to maximize the effectiveness of use of clickers.

This tool encouraged students to voice their ideas and discuss with their peers to reach an agreement. Studies investigating the undergraduate level showed that students were more likely to answer questions correctly after peer discussion than those without peer discussion. Smith and the colleagues used question-answer method to identify the depth of understanding via the use of clickers. Students were required to answer questions individually and then to answer the same questions again after discussion. They individually answered an additional question to test for gains in understanding. It was concluded that students were indeed gaining conceptual understanding from the peer discussion.

Furthermore, studies that used pairs of matched questions revealed that students learned from discussing clicker questions with their peers and this peer-based interaction was especially effective when it was followed by instructor's further explanation.

3.4. Use of Clickers in Large-Scale and Small-Scale Classes

The use of clickers and peer discussion in large-lecture biology courses was hotly discussed. Instructors frequently coupled peer instruction with clickers. Clickers have witnessed growing popularity in recent years, largely due to their role in encouraging all students to participate in lectures, particularly in large classes (Caldwell, 2007 [6]; Cain and Robinson, 2008 [12]; Collins, 2008 [13]). Several studies demonstrated that the use of clickers in lectures improved student performance in undergraduate science classes, reduced cognitive loads and improved listening skills in EFL class. It was shown by several studies that students enjoyed using clickers, felt that this form of interactive engagement was useful for their learning, and they learned from discussing questions with their peers in large-enrollment classes. The possible benefit of the use of clickers in small-scale classes was explored as well, which argued that the use of clickers was beneficial for small-scale classes due to the improvements in peer discussion, pre-class reading and engagement.

3.5. Use of Clickers with Peer Discussion in Problem Solving

Peer discussion could be strongly stimulated by the use of clickers, encouraging more participation in the class. A major challenge instructors confronted in the typical undergraduate classroom was how to encourage all students to practice critical thinking to solve problems in lectures. Clickers were also applied to improvements on problem-solving skills among nursing majors (De-Bourgh, 2008) [14]. Clickers might be able to play a positive role in promoting problem-solving among all students in lectures. It was demonstrated that student learning outcomes in biology classes increased when students were encouraged to engage in cooperative problem solving through either small-enrollment peer instruction or other interactive group activities (Crouch and Mazur, 2001) [10]. The value of peer instruction is sourced from the benefits of class discussion reinforcing concepts.

Previous studies showed that when a student discussed with others, student's perception was enhanced (Chi *et al.*, 1994 [15]; Coleman *et al.*, 1997 [16]). Additionally, students often appreciated hearing explanations from their peers, rather than from the instructor alone, because they could relate to the perspectives of other students more readily. Thus, the increased participation of each student in small-group peer instruction provided the students with an opportunity to discuss with peers. A potential disadvantage of peer instruction was that weaker students might depend on stronger students to work out the answer, rather than attempt to solve the problem on their own. Therefore, the weaker students might still be unable to think independently to finish homework and exam. To diminish the impact of stronger students on weaker ones, independent problem-solving approaches could be coupled with peer instruction. In this way, students would be forced to solve problems independently using clickers before they resorted to peering discussion.

3.6. Use of Clickers among Non-Students

It was studied that whether there was evidence that peer discussion was valuable for adult learners in informal settings among farmers who grew wild blueberries in Maine. The results reported that questions and peer discussion with the assistance of clicker promoted learning and teaching effectiveness among non-student learners, and clickers with peer discussion improved the participation and learning among growers and the learning performance was also raised compared with learners without using clickers.

This study, however, was located on the state border between New South Wales and Victoria. The participants all from this area might not be able to represent a typical but unique case involving local farmers and specialists only. Totally, seven meetings were held. Ten farmers attended the first meeting, but numbers dropped to between five and eight at subsequent meetings. This sample size was therefore not considered enough to represent the population. Worse, group members were mostly male farmers, with merely two women farmers. The disproportion of gender might have resulted in gender bias. Thus, it was hasty to arrive at the conclusion that the use of clickers is effective among non-students.

3.7. Role of Clickers in Knowledge Retention

Retention of acquired knowledge was proved longer for learners with clickers than those without clickers. One study reported insignificantly longer retention for clicker users than non-clicker users. While students who used clickers or online homework systems earned an insignificantly gain than the non-clicker, non-online homework group, students retained knowledge longer in both clicker and online homework classes than lecture-only classes. This finding is contradictory with the well-validated threshold hypothesis in the field of cognitive attrition, which refers to the conception that if the knowledge reached a certain

threshold, then it will be resistant to attrition. If the group did not obtain a significantly better gain, it was hard to believe the group could retain the knowledge longer. Therefore, findings in this study might need further exploration.

3.8. Current Developments in Clicker Use

Recently, a growing number of people have possessed their personal mobile devices such as smartphones. This formed the new trend that students carried smartphones everywhere on campus (Afreen, 2014) [17]. As a result, for convenience and effectiveness, integrating clickers into smartphones is becoming increasingly popular. The commonly used and effective pedagogical instrument is referred to as Kahoot, which is improving the function of clickers by enhancing numerous features.

4. Discussion

Although many studies claimed the benefits of the use of clickers in classes, some studies still denied the benefits of the use of the clicker in classes. Especially in small-scale classes, some lecturers tended to complain that the use of clickers in small-scale classes produced nothing beneficial for learning and teaching but excessive interaction in class. Teachers and students, with clickers, spent too much time on interaction which could have been avoided in traditional classes. Instead of too much interaction, students could focus more on self-learning and self-pondering, which was more helpful to memorize and understand the new conceptions than interaction.

Too much interaction might consume excessive time and students immersed in peer discussion might also diminish their self-understandings and perceptions about the issues. Especially for introverted students, who were not good at communication and discussion, peer discussion might be discouraging for them to join. They preferred thinking and learning by themselves to discussing with peers too much. In small-scale classes, lecturers frequently said they felt convenient to interact with students directly which did not need any computer technology involvement including clickers. Experienced lecturers could exactly judge whether most students perceived the issue or not and determined whether to continue to the next issue or repeat it and further explain it.

Clickers promoted peer participation in class through anonymous voting. However, this device meanwhile frustrated the students who were active learners and thinkers and were ready to respond to teachers' questions openly. On the contrary, they enjoyed the attention drawn through their active performance. With anonymous voting, their activeness was possibly weakened. It was also assumed that learning through clickers might not be helpful for long-term memory (Crossgrove and Curran, 2008) [18] in that students' memory was distracted by discussion and voting. The final argument that needed to be clarified was that whether the use of clickers among non-students was as beneficial as among students since non-students might not be so regulated by the device and less inter-

ested in technology if they were frequently faced with technologies when working.

The effectiveness of clickers in improving student learning is inconclusive; clickers, however, can be used to create a positive learning environment in the classroom, which can doubtlessly help improve learning outcomes. Clickers created a learning environment where all students could participate and be engaged in. Students reported that clickers helped them improve their learning. Clickers allowed for instant feedback and means to evaluate student learning achievements. These formative assessments exerted a positive influence on student beliefs and allowed the teacher to reflect on instructional strategies. They could adjust their strategies in no time since instructors could get students' feedbacks simultaneously.

However, the instruments used to collect data were not fully discussed in terms of reliability and validity. It was questioned that the instruments used to collect data on clickers use might be invalid and unreliable, and thus the credibility of these studies was in question. Merely four studies investigated the reliability and validity of instruments. Most studies on clickers (e.g., Bunce, VandernPlas, and Havanki, 2006) [19] investigated students' perceptions of clickers as engagement and learning with only one or two items, which resulted in worries about both reliability and validity.

Problems in the effective use of clickers were also revealed. Examples are the true influence of clickers on small-scale classes, the impact of peer discussion on different personalities, the influence of anonymous polling on learners with different preferences, the different opinions on interaction with other learners and different attitudes towards technology-involved learning environment, etc.

5. Conclusions

With the swift development of science and technologies, instructional strategies may never move ahead without the aid of technologies. Clickers, as one form of technology, have gained growing popularity due to their advantages, such as peer discussion, anonymity and instant feedback, despite the fact that there are still some defects regarding clickers. More studies on clickers and other new technologies are still needed to further push forward levels of education. Education will lag behind unless it can keep pace with the development of technologies, without which education will possibly fail to keep a leading position. This study paved a solid foundation for future studies on educational technologies via reviewing around one decade's studies on the use of clickers in education. Other techniques which might outweigh clickers in performance were worth exploring as well.

Given the fact that previous studies are more interested in the comparison between effectiveness in clickers and non-clickers aided education, future studies might shift from the focus on comparative studies between clickers and non-clickers pedagogy to the correlation between lecturing and learning aided with clickers.

Future studies on the use of clickers should also take into consideration cross-disciplinary theories, such as computer, learning, psychology, cognition and neurology. Clickers may not be the best choice as a technology used in education. More advanced and convenient technologies should be constantly developed to promote levels of education with cross-disciplinary cooperation.

It is a pity that the paper doesn't show how the clickers can help to improve the teaching efficiency in certain courses, and some of the responses of the students are also needed to show the usefulness of clickers, which will be further discussed in the coming research.

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Conflicts of Interest

The author declares no conflicts of interest.

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