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Increasing classroom engagement and student comprehension through the use of clickers: an Italian secondary school experience

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ABSTRACT

'Clickers' are individual response devices that allow each student to respond to questions presented by teachers. This technology promises to be beneficial since it increases student engagement and provides prompt feedback - two key practices that stimulate learning. Although a number of researchers have studied clickers in higher education and in large classroom settings, there has been very little research in small classrooms and at lower levels. Our research has investigated the role of clickers in five different classes of an Italian grade one secondary school. Two different situations of interactive teaching were compared. In both cases, teachers pose a variety of questions during the course of the explanation, but in the first situation they received answers by "hand-raising", in the second situation through the electronic devices. We wanted to verify differences posed by the use of technology regarding: a) learning outcomes, b) student engagement, c) student's evaluation regarding learning conditions. Results are consistent with other research, which forecasts that students are more cognitively engaged while using clickers; however data showed unexpected differences in learning outcomes based on the subject matter.

KEYWORDS: clickers, student response systems, feedback, learning improvement, student engagement

Giovanni Bonaiuti wrote the following paragraphs: Theoretical framework, Procedure, Data analysis; Antonio Calvani wrote: Research questions, Research instruments, Findings and discussion; Danilo Piazza wrote: Introduction, Participants, Conclusions.

Introduction

A lot of new technologies have been recently proposed in order to promote student participation and stimulate active learning. Clickers are one of these resources, but as unlike others they have their strength in the students' engagement. Clickers, which are also commonly called Student Response Systems (SRS), Classroom Response Systems (CRS), Learner Response System (LRS), Audience Response Systems (ARS), or simply "remotes", are wireless handheld devices that allow students to respond to questions directly from their desks. Software on the teacher's computer collects the students' answers. This information can be used by the teacher alone or, also, shown to everyone through the projector or interactive whiteboard.

The availability of this information, i.e. in the form of a frequency distribution of students' selections to each answer, allows the teacher to make "on the fly" instructional choices in response, for example, deciding whether to spend additional time on certain content, identifying where misunderstanding might be occurring, leading students in a discussion of the merits of each answer chosen or asking students to discuss the question in small groups.

Since international research has emphasized the importance of feedback in education, there has been a growing interest in clickers. Effective forms of feedback provide cues or reinforcement to the learner as well as from the learner to the teacher (Hattie, 2009). Teachers require continuous feedback from learners to know whether they are following the lecture, if they understand or if it is being delivered at an adequate pace (Zarraonandia et al., 2010). Even though it is clear that numerous methods allow for increasing active student responding and associated feedback opportunities, it was recognized that clickers can improve teacher feedback practice in many ways: engaging students, providing immediate feedback to everyone, allowing students response data to be collected automatically, increasing the likelihood of participation by a shy or reticent student (Lantz, 2010). Although a number of researchers have studied student response systems in higher education and in large classroom settings (Caldwell, 2007; Herreid, 2006; Mayer et al., 2009; Mestre et al., 1997; Mollborn & Hoekstra, 2010; Morling et al. 2008; Nicol & Boyle, 2003; Trees & Jackson, 2007) there has been very little research at the K-12 level (Penuel et al., 2007). Our research has investigated the role of clickers in small classrooms in an Italian secondary school.

1. Theoretical framework

Clickers, which have been used in colleges and universities in the USA for years, are now widespread in schools around the world by manufacturers of interactive whiteboards. Several research projects have tried to understand the differences and advantages of this type of technology over non-technical methods for gathering students' responses and feedback (Fies & Marshall, 2006). One of the most obvious answers is that it is not always easy to involve all students with traditional methods (Gedeon, 1997). In a normal class discussion situation, only some students have the opportunity to answer a question. Clickers are not a magic bullet, but the consensus of several literature reviews seems to be that the use

of clickers often increases student attendance, participation, engagement, instructor-student interaction and enjoyment of classes (Caldwell, 2007; Fies & Marshall, 2006; Judson & Sawada, 2002; Roschelle et al., 2004; Simpson & Oliver, 2007).

In order for clickers to really enhance learning they need to be used with an appropriate teaching methodology. Richard Mayer and colleagues (2009) suggest that a particularly interesting way to promote learning is using questioning methods of instruction. They argue that using questioning in classes is a way to promote active learning. Questioning methods of instruction compel students to pay attention to relevant material, mentally organize the selected concepts, and integrate the notion with prior knowledge so that they advance in their knowledge and understanding. Through intensive research in a large lecture course they have shown that an instructional method based on questioning and supported by clicker technology can improve student academic performance producing an effect size of .38 and raise grades by approximately 1/3 grade point (Mayer et al., 2009).

Clickers are a boon because they "increase the ease with which teachers can engage all students in frequent formative assessment" (Roschelle et al., 2004, p. 4). Black and Wiliam (1998) defined formative assessment as "all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged" (Black & Wiliam, 1998, pp. 7-8). They stated that the practice of formative assessment produces significant and often substantial learning gains with typical effect sizes ranging from 0.4 to 0.7, a level of gains that could be considered as quite considerable.

Another concept closely related to that of the formative assessment is feedback. In a synthesis of 800 meta-analyses, Hattie (2009) clearly indicated that feedback was among the most powerful influences on achievement. Most programs and methods that worked best in education are based on heavy dollops of feedback. Feedback is a bidirectional process – from teacher to student and from student to teacher – but, as Hattie pointed out it is most powerful when it is from the student to the teacher: "when teachers seek, or at least are open to, feedback from students as to what students know, what they understand, where they make errors, when they have misconceptions, when they are not engaged – then teaching and learning can be synchronized and powerful. Feedback to teachers helps make learning visible" (Hattie, 2009, p. 173).

Most research on the benefits of using clickers in the classroom has shown that students become engaged and enjoy using them. However, only few studies focus on learning outcomes and their results are rather controversial. Mun and colleagues (2009) reviewing 52 papers on clickers found six true experimental or quasi-experimental studies that compared the learning outcomes (e.g. test scores) of students who used clickers versus those who did not. Results suggested that students who used clickers performed significantly better than those in the traditional lecture. There are, however, several methodological limitations concerning those studies, i.e. poor definition of project design; poor description of the methods used; the lack of tightly controlled comparisons between conditions; the fact that a majority of studies did not report effect sizes in the results or discussion section (Mun et al., 2009). Moreover, although many researchers

have studied clicker effects in higher education and in large classroom environments, there has been very little research at the K-12 level (Penuel et al., 2007). There are examples of papers that show promising effects on achievement, as well as case studies that raised questions about how viable it is to implement clickers in smaller classes, but no specific study that compare clicker use with other questioning methods of instruction in the school context.

2. Methodology

2.1 Research questions

Since many research projects have been carried out on clickers in large classroom situations and at higher education levels we tried to verify how this technology can be accepted in small classes at the K-12 level. To this end, we decided to focus our attention on questioning methods of instruction (Mayer et al., 2009) trying to figure out whether and how clickers can increase its impact. Our study explored both the students' perceptions about their learning and the teachers' about students' commitment. Furthermore we aimed to verify whether the clickers are able to foster understanding and the retention of notions and concepts proposed during a lesson. To do so we studied five different classes (n = 92 students) in two different situations: with and without clickers. Both experiences have provided students the same number of interactions with the teachers: in the first case with questions and answers ("hand-raising condition"), in the second case with the use of clickers ("technological condition"). Both cases adopted questioning as a method to provide feedback: teachers systematically asked questions during the lectures, the students answered and teachers explained the rationale for the correct answers. Even though both situations employed the active learning approach and required students' participation, we wanted to verify differences posed by the use of technology on students' engagement and learning retention.

2.2 Participants

Our pilot research took place in Collegio Villoresi San Giuseppe, a school in Monza in the north of Italy. The study took place during the school year 2012-2013 in five sections of a first grade secondary school. Participants in this study included 92 students, 12–14 years old, (45 male, 47 female) and 5 teachers (1 male, 4 female).
Teachers taught two different disciplines, grammar (n=2) and history (n=3), during 55-minute lessons each on different days. The whole experience lasted 12 weeks.

Figure 1. Students using clickers during the experience at the Collegio Villoresi of Monza

2.3 Procedure

Our experience was started in November after a period of use of clickers in class aimed at their familiarization. The introduction of a new technology, in fact, could represent an element that upsets the routine. After that the five classes had a series of lecture sessions, on different days, with and without clickers. In both experimental situations teachers tried to follow the same teaching schema adopting questioning as a method to foster participation and increase understanding. During each 55-minute lesson teachers spent their first 5 minutes reviewing the previous lectures' content, then teachers explained the new topic taking care to ask questions frequently and finally they submited to the students a test to assess their comprehension (see fig.2). More than 8 "question and answer" sessions were done during each lesson since, as suggested by Mayer and colleagues (2009), it appears that questioning methods of instruction - such as adjunct questions, practice testing, and self-explanation - can be effective to stimulate attention to relevant material, encouraging organization and integration with prior knowledge.
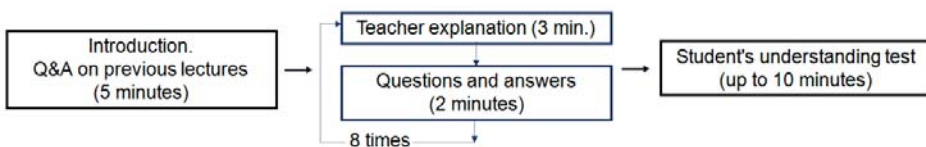

Figure 2. Flow chart of lessons: each lesson was composed of three parts: opening, instruction, student's evaluation. During the instruction phase more than 8 Q&A sessions were done

Using the same teaching plan teachers conducted four different lessons: two without and two with the clickers. In both experimental situations teachers provided students with the same number of interactions: in the first case with questions and answers by "hand-raising", in the second case with the use of clickers. To guarantee a more active involvement we required "open-ended responses" in both situations. For example, a history teacher asked questions like "Why do we use the term Renaissance?" or "What was the purpose of patronage in the Renaissance?" while a grammar teacher asked questions like "What is an arti-

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cle?" or "What are partitive articles?". In hand raising situations students orally exposed their responses, while in the clickers situation through keyboard. Our clickers, in fact, allowed the students to write short sentences in answer. The teachers displayed the answers on their computer monitor ensuring, in this way, the anonymity of the responder. In order to verify the difference between the two methods at the end of each lesson the students carried out a test of understanding. Furthermore, at the end of each group of lessons, students were asked to fill out a questionnaire about the questioning methods of instruction with and without clickers (see fig. 3).
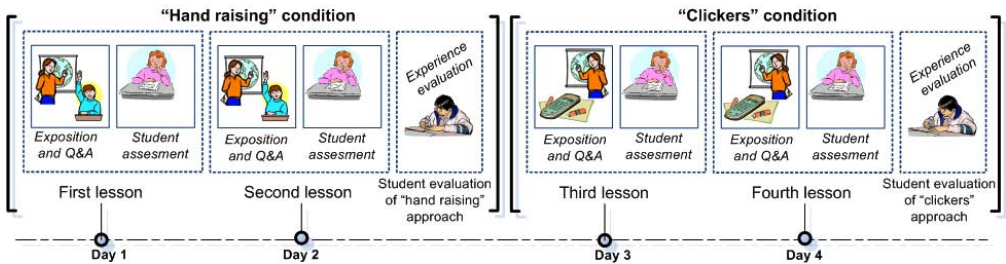
Figure 3. Timeline of the experience: the first two lessons were done in "hand raising" condition, the last two with clickers

2.4 Research instruments

The study used a mixed approach combining the use of quantitative and qualitative analysis. At the end of each lesson each student carried out a verification test about content's comprehension. Each test consisted of at least 15 items divided between items relating to facts (e.g. in what year was America discovered?), concepts (e.g. what does discovery mean?) and relationships between facts and concepts (e.g. what were the consequences of the discovery of America?). After the second lesson and after the fourth lesson an anonymous survey was administered to investigate the students' evaluation of the two approaches. Each survey was composed of five Likert-type items with a 5-point agreement response scale (1=Strongly disagree, 5=Strongly agree). Sample items were "Participation with clickers (or "hand raising" discussion) improves my understanding", "I would recommend using clickers (or "hand raising" discussion) again, also in other subjects matter". In addition to the survey, students were asked to fill out a semantic differential to further estimate students' perceptions of the two approaches. As it is known semantic differential is a type of a rating scale designed to measure the connotative meaning of objects, events, and concepts. In our case the connotations are used to derive the attitude towards clickers through the use of nineteen pairs of adjectives such as: natural/artificial, warm/cold, quiet/anxious, productive/unproductive, and stimulating/inert. Moreover we carried out a series of classroom observations during the two types of lessons that provide to record, for each student, the number of times that

he/she raises his/her hand in the situation "without clickers". At the conclusion of the research project we also asked teachers to complete a survey about the clickers. The teachers' survey was composed of five Likert-type items with a 5-point agreement response scale and five open-ended questions. Sample items were "Clickers promote understanding", "Clickers let the teacher have information usually unavailable", "and Clickers change the pace of the lesson". Furthermore, at the end of the whole experience teachers and students discussed the overall results in class and tried to identify the reasons for successes and failures.

3. Data analysis

The data showed that students are actually more engaged when using the clickers. While in the clicker situations all of the students in the class are involved, the result of observation in a traditional situation, shown in fig. 4, displays that the majority of students participated only once and 18% of them never raised their hands during the lessons.
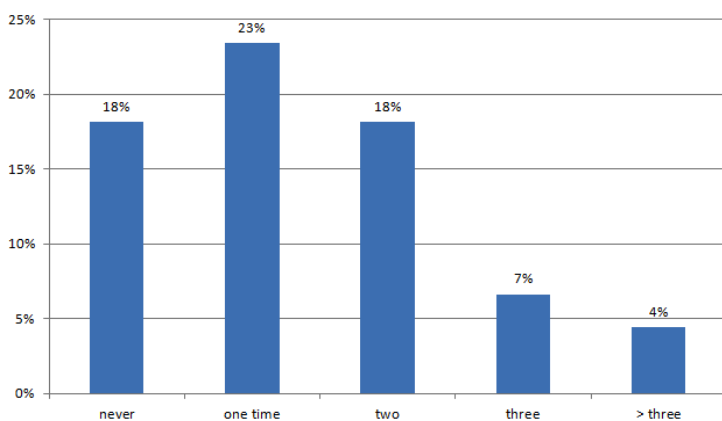

Figure 4. Students involved in discussions in a "hand raising" situations (n=92 students)

The score of the two anonymous students' surveys, administered at the end of the two series of lessons, show that students appreciate both approaches. All entries exceed the average size. This fact is particularly interesting because even a "question and answer approach" by hand-raising is uncommon for students. As pointed out by Hattie (2012) classrooms are dominated by teacher talk, and one of the themes to improve learning is that the proportion of talk to listening needs to change to far less talk and much more listening. Usually the lessons are poorly interactive and it is sufficient that teachers change the way of explaining the subject content to get a clear signal of appreciation. However, some dimensions show a clear separation between clicker and non-clicker conditions (fig.5). The clickers were particularly appreciated for their ability to promote engage-

ment (M = 4.48; SD = 1.02), enjoyability (M = 4.42; SD = 1.01) and attention (M = 4.09; SD = 1.07).
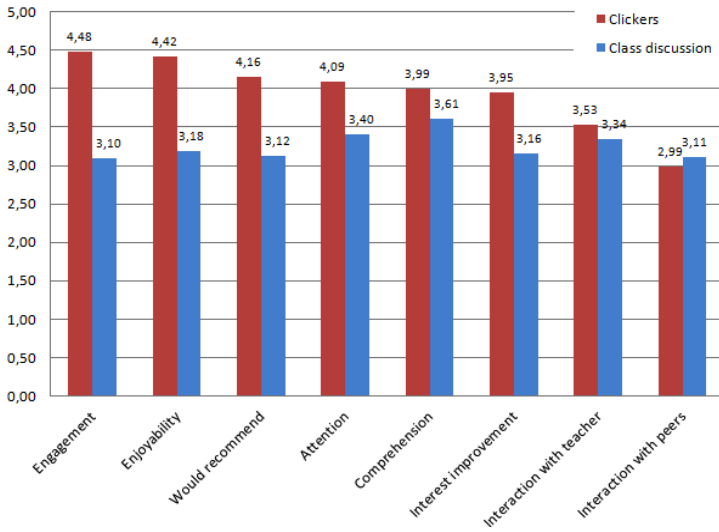
Figure 5. Students' perception survey (n=92). Likert scale: 1=Strongly disagree, 5=Strongly agree

The positive perception of clickers by students is also confirmed by the semantic differential showing a high prevalence of positive connotations (fig. 6).
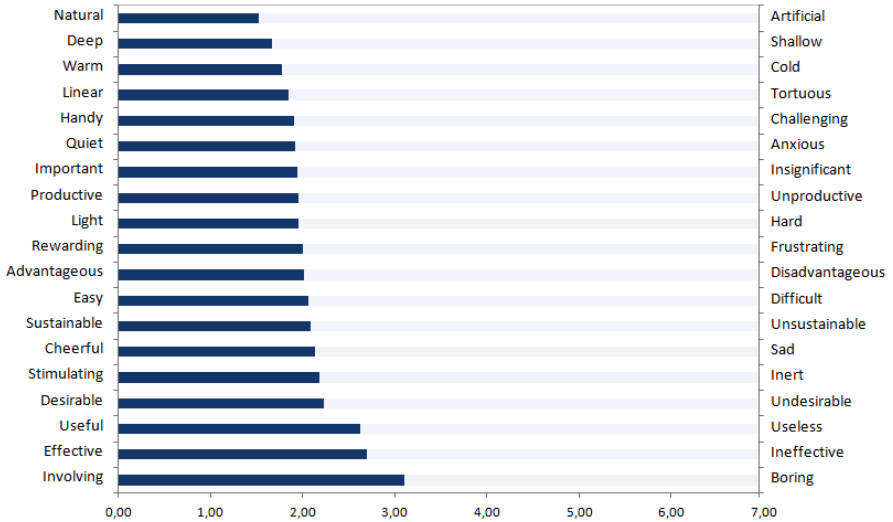

Figure 6. Students' responses on semantic differential (n=92 students)

Teachers evaluated the use of clickers positively (fig. 7), albeit with a few caveats expressed in open-ended responses. They appreciated the fact that all students have the opportunity to participate and they stated that clickers solicit reasoning before taking action or, in other words, clickers contribute to impulsivity control. On the other hand clickers present risks that pupils only see the playful aspect of the experience with possible interference in the cognitive process of understanding the content. Moreover the clickers' use requires a lot of preparatory work and slows down the pace of the lesson.
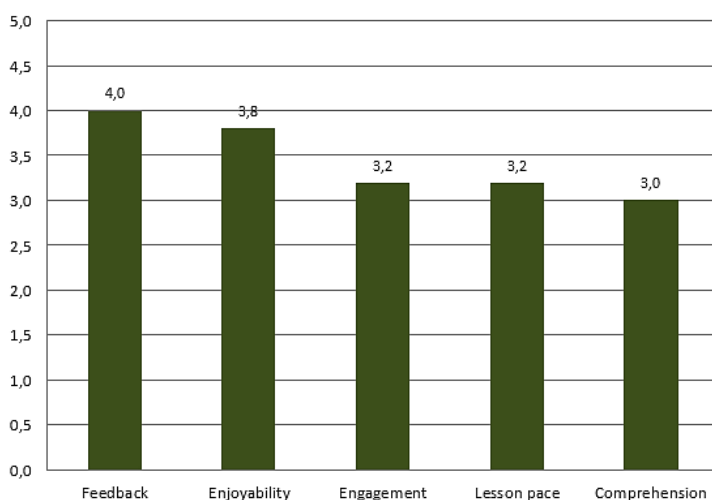
Figure 7. Teachers' perception survey about clickers' effect on the students' behaviour (n=5). Likert scale: 1=Strongly disagree, 5=Strongly agree

Unforeseen were the results of the comprehension tests administered to students at the end of each lesson. The total number of errors committed in the tests performed after two lessons with and without clickers are different in history and grammar. Errors in grammar decrease in clicker conditions, whereas they increase in history (see tab.1).

	Situation		N. of items	N. of errors	% of errors
History	Hand-raising	(lesson 1 + 2)	1434	360	25.10 %
	Clickers	(lesson 3 + 4)	1434	503	35.08 %
Grammar	Hand-raising	(lesson 1 + 2)	1080	133	12.31 %
	Clickers	(lesson 3 + 4)	1080	91	8.43 %

Table 1. Comparison of students' performance at the final comprehension test. Results are calculated considering only students participating in all four tests (N=37 in history, N=35 in grammar)

The percentage of errors in the "hand raising" condition is 12.31% whereas in the "clickers" condition, the percentage is 8.43% (*ES* = .32). Vice versa, the percentage of errors in history is lower in "hand raising" situations, 25.10%, and increased with clickers: 35.08%. In this case the effect size was negative (*ES* = -.50) or, in other words, the technological situation seems to worsen learning. In both cases results are statistically significant at Wilcoxon test (α=.01).
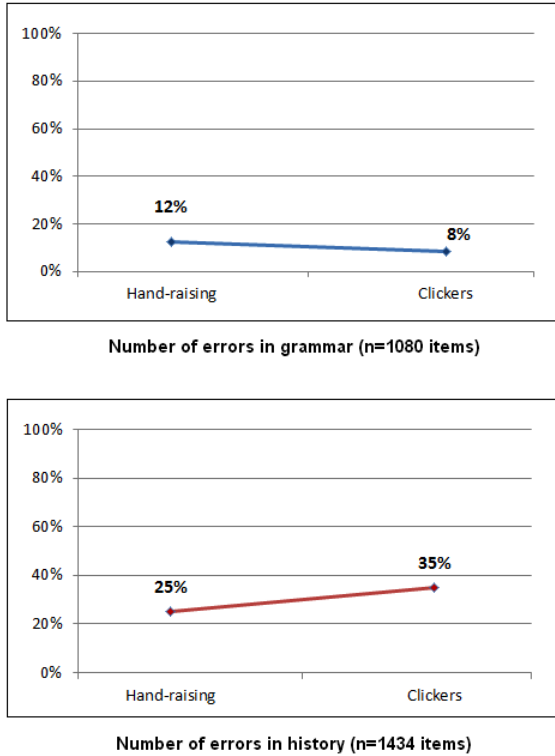
Number of errors in grammar (n=1080 items)

Number of errors in history (n=1434 items)

Figure 8. Overall results of the end of the lesson students' comprehension test

4. Findings and discussion

In this study, we endeavour to examine various effects of clickers on teachers and students. The data and comments from interviews indicated that clickers provide an interesting way for students to participate in classroom discussion. As has been noted by other works, questioning is inherently motivating and focuses students' attention on learning (Mayer et al, 2009). In light of this, clickers could provide opportunities to make classroom lessons more interactive, thereby raising students' interest and engagement (Fies & Marshall, 2006; Kay & Knaack, 2009; Simpson & Oliver, 2007). The students also identified the benefits of anonymity of responses and immediate feedback as facilitators to understand

concepts. As pointed out by Freeman and colleagues (2006) anonymity, as afforded by clickers, is a critical factor affecting student willingness to participate with in-class questions because they feel free to provide their responses without fear of failure. Overall, in our trial, students and teachers stated that clickers have increased interest and participation.

Even though, at the end of the experience, our teachers have also highlighted some critical aspects such as: using clickers in class takes up class time; writing effective questions can be a tough job; leading class-wide discussions can be challenging for teachers used to just lecturing; for the students the fun can lead to loss of concentration.

The most debatable question, however, is the results at comprehension tests. The students in this study demonstrated higher scores on final tests only when clickers were used in grammar lessons. Conversely, worst results were obtained in history. It seems that the use of clickers could be influenced by the subject matter and, conceivably, by the type of specific topic. Students and teachers were asked to analyse and interpret these data. The most reliable hypothesis is that the arguments in grammar were more clearly defined and the questions were much more precise than in history. The presentation of the contents in history, given its narrative character, was put in practice in a more dispersive and less controllable way than in grammar. Whenever a teacher asks a question during the lesson, he/she restricts the students' attention to that specific topic. Since clickers operate as an amplifier which enhances this effect, it could be possible that the students tend to pay less attention to the rest. Due to the fact that topics covered in history lessons were quite numerous, and only some of the questions included in the final tests were posed during the lessons, it may have led to a reverse effect. The problem did not arise in grammar because the concepts were fewer and better defined. In complex subject matters the development of good questions that must be carefully designed and intertwined into lecture becomes more critical.

Since there are no other studies to compare our data, further research is needed to better understand whether there is a relationship between subject area and learning effect and in which specific disciplinary contexts is it more appropriate to use them than others.

Conclusions

In this study, we investigated the impact of clickers' use in small classrooms of an Italian first grade secondary school. Teacher's and students' perceptions with regard to using clickers were generally positive. Based on the evidence to date, clickers promise new opportunities to promote students interaction. Results are consistent with other research, which predict that students in technological conditions are more cognitively engaged during learning. Despite this, the clickers' effects on improving learning are not univocal in our research. The use of clickers seems to lead to an improvement in grammar, but not in history. There are some limitations in this study including: sample size, single site context, short study time period and self-selected participant teachers. However, all research requires a starting point from which to build, and we believe that our work has resulted

in sufficient data to demonstrate that further work is merited to fully understand the potential use of this technology and to determine whether there is a relationship between subject area and learning effect or, if there are really subject matters where clickers are more advisable than others.

Acknowledgements

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