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Do clickers enhance learning? A control-value theory approach

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ABSTRACT

The use of clickers in the classroom has gained popularity over the past few years. While significant work has been conducted on exploring clickers as drivers of learning outcomes, findings are still mixed and inconclusive. In addition, several recent reviews of this interactive technology highlight an important shortcoming of previous research: the lack of theoretical discussions that explain how clickers may help learning. To address these gaps, this research draws on the control-value theory of achievement emotions to explain how the use of clickers can enhance students' motivation, learning, and satisfaction. Based on a survey of 207 undergraduate students who use clickers in the classroom, the findings show that feedback provided by clickers has a positive influence on students' perceived academic control, self-efficacy, and value. Perceived academic control and self-efficacy positively predict pride, but do not influence the enjoyment experienced while using clickers. On the other hand, self-efficacy has a negative influence on boredom. Value has a positive effect on enjoyment and pride, and a negative effect on boredom. Enjoyment experienced by students while using clickers predicts both intrinsic and extrinsic motivation. Pride has a positive effect on extrinsic motivation, whereas boredom has a negative influence on students' intrinsic motivation. Finally, both types of motivation predict perceived learning and satisfaction.

1. Introduction

The use of clickers in academic settings has gained popularity over the past few years, becoming an important topic of research for both scholars and educators across different disciplines. Clickers are small, portable devices that look similar to a television remote control (Blasco-Arcas, Buil, Hernández-Ortega, & Sesé, 2013) and use radio-frequency or infrared technology to transmit and record student responses to questions presented in the classroom. Due to the real-time feedback provided by clickers, students can assess their level of understanding of the material being taught (Sun, 2014), whereas instructors are provided with an opportunity to manage classroom discussion about concepts being covered (Kay & LeSage, 2009). Different forms of instruction that integrate clickers are commonly found in the literature (Chien, Chang, & Chang, 2016). The simplest way of using clickers is to ask students to respond to a question individually. In addition to this most

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common use, clickers can be used with teams of four or more students, encouraging peer discussion and collaborative learning (McDonough & Foote, 2015). Clickers can also be used as a tool to encourage friendly competition among peer groups. In addition, using the motivational pull of games, clickers can make traditional lecture-style classes more appealing to students, engaging them in the learning process (McGonigal, 2011).

In the past few years, a growing number of empirical studies have explored the effects of clickers on learning outcomes (e.g., Blasco-Arcas et al., 2013; Castillo-Manzano, Castro-Nuño, López-Valpuesta, Sanz-Díaz, & Yñiguez, 2010; Ludvigsen, Krumsvik, & Furnes, 2015; McDonough & Foote, 2015; Stowell, 2015; Sun, 2014). However, findings are still largely mixed and inconclusive (Hunsu, Adesope, & Bayly, 2016). In addition, several recent reviews on research into clickers (Chien et al., 2016; Hunsu et al., 2016) have highlighted an important shortcoming of previous research: the lack of theoretical discussions that explain how clickers may help learning. In this sense, Chien et al. (2016, p. 747) stated that empirical studies "should be conducted in a more rigorous manner, to provide explanations for academic learning outcomes through explicit incorporation of a theoretical framework." In response to this, the current research draws on the control-value theory of achievement emotions developed by Pekrun (2000, 2006) to explain how the use of clickers can improve students' motivation, learning, and satisfaction. Students can experience different emotions, such as enjoyment, pride, or boredom, while using clickers. These achievement emotions, defined as those that are directly tied to achievement activities or achievement outcomes (Pekrun, 2006; Pekrun, Frenzel, Goetz, & Perry, 2007), are critical for students' learning, performance, and motivation, among other variables (Schutz & Pekrun, 2007). Therefore, this theory, which offers an integrative approach to analyzing the emotions experienced in academic settings, is a useful framework for explaining why the use of clickers can facilitate academic learning outcomes.

More specifically, we investigate both the antecedents and consequences of students' achievement emotions while using clickers. First, we explore the influence of the feedback provided by clickers on students' perceived academic control, self-efficacy, and value. In addition, we examine the effect of students' perceived academic control and self-efficacy over the activity in which clickers are used, as well as the value students assign to this activity, on students' positive and negative achievement emotions. In particular, three relevant achievement emotions in the learning context (i.e., enjoyment, pride, and boredom) are analyzed in this study. Finally, we investigate the impact of achievement emotions experienced while using clickers on students' motivation, perceived learning, and satisfaction.

This article contributes to the literature in two ways. First, building on control-value theory, we offer a conceptual framework for understanding why the use of clickers may facilitate learning outcomes. In addition, our empirical findings provide new insights into the effectiveness of clickers. Second, despite the recent increase in the number of studies that have explored achievement emotions, the development and influence of achievement emotions, other than anxiety, on performance remain under-researched and scholars have highlighted the need to investigate their effects further (Pekrun, 2006; Pekrun, Elliot, & Maier, 2009; Peterson, Brown, & Jun 2015). This study addresses this request.

This paper is structured as follows. It opens with a brief discussion of clicker technology. The conceptual model and hypotheses are then presented. This is followed by the methodology and analysis of empirical findings. Finally, the paper outlines the conclusions, implications, and limitations of the research.

2. Clickers in the classroom: pros and cons

Clickers, also referred to as Audience Response System, Student Response System, Classroom Communication System, Clicker Assessment and Feedback, or Audience Response Technology (Han & Finkelstein, 2013), allow students to respond to questions in the classroom. Once the instructor asks a question, which is generally displayed on a screen, students can click the buttons on their remote-like devices to answer the question. A receiver connected to a computer collects students' responses. The computer software records and summarizes the responses. The results are automatically presented to the class in visual format, usually via a histogram. This feedback is visible to the whole class and benefits both the teacher, by providing him or her with information on the level of understanding and guidance on how to adapt the content of the lecture, and the students, by assessing their knowledge and level of preparation (Blasco-Arcas et al., 2013; Sun, 2014). In this sense, students can compare their answers with those of their peers and see whether they need to change their preparation or learning strategies (Kay & LeSage, 2009). Although responses are anonymous to peers, the teacher can associate the clicker unit ID with specific students. Thus, clickers can also be used for evaluation or recording students' attendance.

Previous studies have revealed that the use of clickers is associated with different positive outcomes (Kay & LeSage, 2009). Using clicker-based technologies facilitates students' active collaborative learning, and encourages interaction and engagement (Blasco-Arcas et al., 2013; Simpson & Oliver, 2007). Clickers also positively influence students' experiences in the classroom (Han & Finkelstein, 2013; Simpson & Oliver, 2007), enhance classroom attendance and attention (Keough, 2012), facilitate anonymity and participation (Carnaghan, Edmonds, Lechner, & Olds, 2011), and increase students' motivation and satisfaction (Marshall, Valdosta, & Varnon, 2012). In comparison to other techniques, the use of clickers has also been found to increase students' enjoyment (Stowell & Nelson, 2007; see Kay & LeSage, 2009, and Rana, Dwivedi, & Al-Khowaiter, 2016 for a more detailed analysis of the benefits of using clickers).

Despite their numerous benefits, there are also some challenges regarding the use of clickers in class. Clickers can be stressful for students due to technological issues, such as when remote devices do not function properly, and the greater cognitive energy required from students (Kay & LeSage, 2009). In addition, some teachers are reluctant to integrate clickers into the learning process because of their high cost in terms of time and effort (e.g., writing good questions and responding to

students' feedback; Kay & LeSage, 2009) and interruption in the flow of the class (Koenig, 2010; Strasser, 2010). Finally, the use of clickers can be costly for most educational institutions, which is also a barrier to their adoption (Blasco-Arcas et al., 2013; Rana et al., 2016).

3. Conceptual framework and hypotheses

3.1. Control-value theory of achievement emotions

The control-value theory of achievement emotions (Pekrun, 2000; Pekrun, Elliot, & Maier, 2006; Pekrun, Goetz, Titz, & Perry, 2002) provides an integrative framework for understanding the emotions experienced in achievement and academic settings and for analyzing their antecedents and effects. It builds on propositions from different theories, such as attributional theories, expectancy value approaches to emotions, perceived control theories, transactional theories of stress appraisals and related emotions, and models of the performance effects of emotions (Pekrun et al., 2007). According to control-value theory, there are three important academic settings to experience emotions in a course, such as being in class, taking tests and exams, and studying outside of class. Each of these settings promotes different types of emotions, such as class-related, test-related, and learning-related emotions. Additionally, the control-value theory posits that emotions are considered as an assortment of different psychological processes that are interrelated, whereby affective, cognitive, motivational, and physiological components are of main importance (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011).

Achievement emotions are defined as those that are directly associated with achievement activities or achievement outcomes (Pekrun, 2006; Pekrun et al., 2007). Prior to the control-value theory, studies on achievement emotions focused only on emotions relating to achievement outcomes, including *prospective outcome emotions* (e.g., hope and anxiety linked to possible success and failure, respectively) and *retrospective outcome emotions* (e.g., pride or shame experienced after feedback on achievement; Pekrun, 2006; Pekrun et al., 2011). The definition proposed by the control-value theory implies that emotions pertaining to achievement-related activities are also considered achievement emotions (Pekrun, 2006; Pekrun et al., 2007). Examples of *activity emotions* are students' enjoyment of learning, boredom experienced during classroom instruction, or anger about task demands. The differentiation of activity emotions versus outcome emotions pertains to the *object focus* of achievement emotions. Additionally, achievement emotions can be grouped according to their *valence* (positive vs. negative), and the degree of *activation* implied (activating vs. deactivating; Pekrun et al., 2007). Using these two dimensions, emotions can be categorized into four groups: *positive activating emotions* (e.g., enjoyment, pride, and hope), *positive deactivating emotions* (e.g., relief), *negative activating emotions* (e.g., anxiety, anger, and shame), and *negative deactivating emotions* (e.g., boredom and hopelessness; Pekrun et al., 2002).

The control-value theory holds that appraisals of *control* and *value* are key determinants of achievement emotions (Pekrun, 2006). Briefly, control appraisals relate to the perceived controllability of achievement actions and outcomes, whereas value appraisals refer to the subjective importance of those activities and outcomes (Pekrun et al., 2011). In addition, the control-value theory posits that students' perceptions of *control* and *value* are influenced by factors related to students' learning environment and teachers' occupational environment, such as cognitive quality of instruction, task demands, autonomy support and cooperation, goal structures, or feedback on success and failure. Finally, the theory also addresses the effects of achievement emotions on students' learning and performance, which are mediated by a number of cognitive and motivational mechanisms, such as students' motivation to learn, cognitive resources, use of learning strategies, and self-regulation vs. external regulation of learning (Pekrun, 2006; Pekrun et al., 2002).

Considering that students can experience different achievement emotions, such as enjoyment, pride, or boredom, while using clickers, the control-value theory provides a relevant conceptual framework to account for the effectiveness of this technology.

3.2. Research hypotheses

Fig. 1 shows the proposed model underlying this research. Specifically, drawing on the control-value theory, feedback provided by clickers is proposed to positively influence control and value appraisals (i.e., perceived academic control, self-efficacy, and value), which in turn affect students' positive and negative achievement emotions (i.e., enjoyment, pride, and boredom). In addition, the model proposes that achievement emotions experienced while using clickers influence students' intrinsic and extrinsic motivation, which in turn impact students' perceived learning and satisfaction.

Pekrun et al. (2002) originally identified enjoyment, hope, pride, relief, anxiety, anger, shame, boredom and hopelessness as the main discrete academic emotions experienced in academic settings. Widely accepted in the literature, these emotions have been studied in the last years in different contexts. However, as recently pointed by Peterson et al. (2015, p. 85), achievement emotions research usually focuses on emotions "more or less in isolation" (e.g., boredom in Acee, Kim, Kim, Kim, Chu, Kim et al., 2010; Fritea & Fritea, 2013; Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010; anxiety in Hong, Lin, Hwang, Tai, & Kuo, 2015; Singh, Bhadauria, Jain, & Gurung, 2013; enjoyment in Giannakos, 2013; enjoyment and boredom in Noteborn, Carbonell, Dailey-Hebert, & Gijselaers, 2012; enjoyment and pride in Villavicencio & Bernardo, 2013). In addition, not all of the emotions identified by Pekrun are equally common during the class (Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007). Therefore, as explain next, three emotions particularly salient in academic settings (i.e., enjoyment, pride, and boredom) were analyzed in this research.

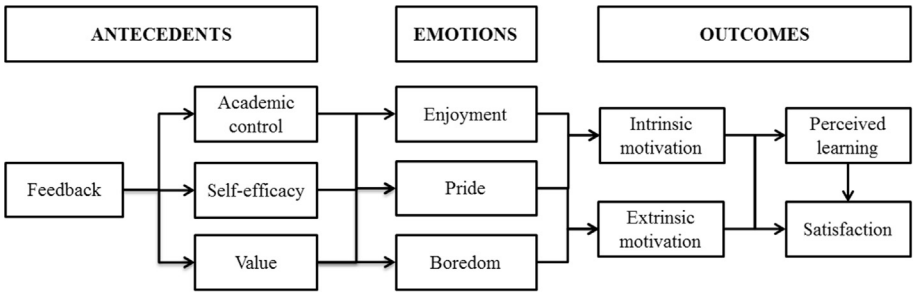

Fig. 1. Proposed model.

As recent studies show, enjoyment arises as one of the most important emotions experienced by students (e.g., Goetz, Pekrun, Hall, & Haag, 2006; Niculescu, Tempelaar, Dailey-Hebert, Segers, & Gijselaers, 2015; Noteborn et al., 2012; Villavicencio & Bernardo, 2013; You & Kang, 2014), especially when analyzing the impact of games in educational contexts (Giannakos, 2013). As opposed to enjoyment, which has been found to have a positive impact on students' learning outcomes (Pekrun et al., 2002), boredom triggers impulses to escape any situation and relates negatively to attention in class, motivation, and performance (Pekrun et al., 2010). It has been analyzed in deep in several studies (e.g., Acee et al., 2010; Fritea & Fritea, 2013; Noteborn et al., 2012; Tempelaar, Niculescu, Rienties, Gijselaers, & Giesbers, 2012; You & Kang, 2014) as it is also one of the most important academic emotions for its implications on students' achievement. Finally, pride, which denotes a sense of self-satisfaction after a success, is also particularly salient in academic settings (Goetz et al., 2006). Several studies have found that pride is one of the most felt positive emotions, being reported even more than enjoyment (Goetz, Haag, Lipnevich, Keller, Frenzel, & Collier, 2014; Hanin & Van Nieuwenhoven, 2016).

In short, enjoyment, boredom and pride are often experienced by students in academic settings (Pekrun et al., 2002). In addition, they are important for students' learning, performance, and motivation in clicker competition settings. Clickers can make traditional lecture classes more appealing to students, increase students' enjoyment and pride, and help avoid boredom (Hoekstra, 2008; Stowell & Nelson, 2007). Therefore, the study of these achievement emotions is especially relevant.

3.2.1. Antecedents of achievement emotions

As explained above, the control-value theory of achievement emotions postulates that physiological processes, genetic dispositions, and cognitive appraisals are the main sources of emotions. However, neither physiological processes nor the genetic dispositions of students are beyond the control of educators (Pekrun et al., 2002). For this reason, cognitive appraisals are of specific relevance for achievement emotions. In particular, within this theory two categories of cognitive appraisals are proposed as determinants of achievement emotions: subjective control over achievement activities and their outcomes, and the subjective value of these activities and outcomes (Pekrun, 2006). In other words, achievement emotions are inferred when students feel "in control of, or out of control of, activities and outcomes that are subjectively important" for them (Pekrun et al., 2011, p. 38).

Two types of control appraisals have been identified in the literature (Pekrun et al., 2011): perceived academic control and self-efficacy. Perceived academic control refers to students' beliefs about whether they can intentionally predict and influence outcomes in their academic environment (Stupnisky, Renaud, Daniels, Haynes, & Perry, 2008). On the other hand, self-efficacy is defined as students' beliefs about their ability to complete a task successfully under certain conditions (Bandura, 1977). Finally, value appraisals relate to the subjective importance of activities and outcomes (Pekrun et al., 2011). The value of an activity can be intrinsic (e.g., when students engage in an activity per se, although it does not produce any relevant outcome) or extrinsic (e.g., when students value the utility of activities to produce external, desired outcomes; Pekrun et al., 2007).

In addition, the control-value theory of achievement emotions assumes that there are different environmental factors that influence students' control and value-related appraisals (Pekrun et al., 2002). Among all environmental factors, feedback on achievement is of major importance for our study because it is a distinctive feature of clickers. The use of clickers offers two types of information as feedback: first, display of the voting results; and second, instructors' explanations for the answers to questions (Chien et al., 2016).

According to the control-value theory, feedback on success or failure at learning implies information about the probability of future success or failure, thus having an impact on control and value appraisals (Pekrun, 2006). Therefore, based on these theoretical assumptions, it is proposed that the feedback provided by clickers will have a positive impact on perceived academic control, self-efficacy, and value.

H1: Feedback has a positive influence on (a) perceived academic control, (b) self-efficacy, and (c) value.

There are manifest connections between individuals' appraisals and achievement emotions (Pekrun et al., 2002, 2007, 2011). In general terms, control-related appraisals (perceived academic control and self-efficacy) correlate positively with students' positive emotions and negatively with negative emotions. For instance, students' academic control in university

settings has been found to have a positive impact on students' enjoyment and hope (González, Donolo, Rinaudo, & Paoloni, 2011), but a negative impact on students' boredom and anxiety (Stupnisky, Perry, Renaud, & Hladkyj, 2013; Tempelaar et al., 2012; You & Kang, 2014). Additionally, students' self-efficacy has been found to be correlated positively with joy (Pekrun, Goetz, Perry, Kramer, Hochstadt, & Molfenter, 2004) and negatively with anxiety (Singh et al., 2013). Regarding value-related appraisals, thinking that an activity is valuable is negatively correlated with experiencing boredom during the activity (Noteborn et al., 2012) and positively correlated with positive emotions such as enjoyment and hope (González et al., 2011).

Although further investigation is needed to test assumptions for some emotions addressed by the control-value theory, there is ample evidence from a number of sources to corroborate the predictions for enjoyment, pride, and boredom (Pekrun et al., 2007). First of all, enjoyment is prompted when the activities are experienced as both controllable and valuable (Pekrun et al., 2011). Several studies have found that enjoyment is high when both control and value are high, and low when either control or value or both are low (González et al., 2011; Pekrun et al., 2002, 2007). Conversely to enjoyment, boredom is induced when the activity lacks value (Pekrun et al., 2011). Boredom may serve as a way of escaping from situations that do not provide sufficient stimulation to students, but also from situations that are beyond the students' capabilities (Pekrun et al., 2002). Finally, pride is also assumed to be control dependent (Pekrun, 2006; Pekrun et al., 2007). This emotion is posited to be induced by attributions of success and failure to the self (Pekrun et al., 2007), implying control over the outcomes (Pekrun et al., 2011).

According to this argument, if students are interested in the clicker activity and feel capable of taking part in it, they will experience enjoyment. In contrast, clicker-related boredom will be a signal that students have a strong sense of being able to master the activity, but do not value it. Finally, in the context of collaborative learning, students will feel pride if they consider that their contribution to the group has made the group win, so success can be attributed to students' control over the clicker activity and over the subject content. Based on these assumptions, we propose the following hypotheses:

H2: Perceived academic control has a positive influence on (a) enjoyment, (b) pride, and (c) boredom.
H3: Self-efficacy has a positive influence on (a) enjoyment and (b) pride, and a negative influence on (c) boredom.
H4: Value has a positive influence on (a) enjoyment and (b) pride, and a negative influence on (c) boredom.

3.2.2. Outcomes of achievement emotions

According to the control-value theory, achievement emotions affect students' learning and academic performance (Pekrun et al., 2009, 2011, 2007) by influencing their motivation and effort, their self-regulation, and their use of learning strategies. In our study, we focus on the direct effects of students' achievement emotions on both intrinsic motivation, which refers to the motivation to participate in an activity because it is interesting and enjoyable, and extrinsic motivation, which relates to the achievement of positive outcomes (e.g., good marks) or to the prevention of negative outcomes (e.g., poor marks; Pekrun et al., 2011).

Positive activating emotions such as enjoyment and pride have a positive influence on students' motivation and academic performance (Pekrun et al., 2004, 2009, 2011). They promote both intrinsic and extrinsic motivation, facilitating flexible learning and self-regulation, and helping the learner to focus attention on the task at hand (Pekrun et al., 2002, 2004, 2011). In contrast, negative deactivating emotions, such as boredom, are detrimental to students' motivation, as they direct attention away from the task, making any processing of task-related information shallow and superficial (Pekrun et al., 2002, 2009). Therefore, it is hypothesized that positive emotions (i.e., enjoyment and pride) will enhance both types of motivation, while negative emotions experienced while using clickers (i.e., boredom) will undermine them.

H5: Enjoyment has a positive influence on (a) intrinsic motivation and (b) extrinsic motivation.
H6: Pride has a positive influence on (a) intrinsic motivation and (b) extrinsic motivation.
H7: Boredom has a negative influence on (a) intrinsic motivation and (b) extrinsic motivation.

The effect of intrinsic and extrinsic motivation on learning outcomes (i.e., perceived learning performance and students' satisfaction) is explored next. Different operational definitions for learning can be found in previous research. In most studies, learning outcomes have been measured as “achievement” or “performance” based on grades (Giannakos, 2013; González et al., 2011; Mega, Ronconi, & De Beni, 2014; Noteborn et al., 2012; Tempelaar et al., 2012). However, the use of grades may not always provide the best measure (Rovai & Barnum, 2003). In this sense, final course grades do not always reflect “pure” learning, but other considerations such as classroom participation and attendance (Caspi & Blau, 2008). Furthermore, grades, particularly for performance tests, may not be a reliable measure of learning, as teachers are unlikely to assign grades consistently (Rovai, 2002). Additionally, grades tend to have restricted ranges, thus limiting their use in correlation studies (Rovai, 2002). Therefore, the use of grades as a measure of learning can be problematic. Alternatively, other perspectives on learning, such as the cognitive perspective, which regards learning as changes in one's mental models or knowledge representations (Shuell, 1986), consider that learning outcomes can also be assessed through students' perceptions of learning outcomes (Alavi, Marakas, & Yoo, 2002). Therefore, this study explores perceived learning to measure the beliefs and feelings that students have regarding the learning experience (Caspi & Blau, 2008), as well as students' satisfaction, which is also an important learning outcome (Klein, Rossin, Guo, & Ro, 2010).

The model proposed by Pekrun (1992) posits that achievement emotions influence motivational variables that, in turn, have an impact on students' achievement. As intrinsic motivation theorists have argued, being motivated, interested, and engaged in the learning process results in better learning and achievement (Cordova & Lepper, 1996; Deci & Ryan, 1985). Empirical evidence has also shown the positive effect of motivation on academic achievement (e.g., Lepper, Henderlong, & Iyengar, 2005; Mega et al., 2014). Students with a higher level of motivation experience a higher level of user satisfaction and perceive that their learning outcomes are better (Eom, Wen, & Ashill, 2006). Therefore, there is ample evidence that improvements in students' perceived learning and satisfaction can be expected if students experience a class where clickers are used as a rewarding experience that motivates them (Guo, Klein, Ro, & Rossin, 2007; Klein et al., 2010; Rossin, Ro, Klein, & Guo, 2008). Thus, we hypothesize that both intrinsic and extrinsic motivation will have a positive effect on students' perceived learning as a result of using clickers and their satisfaction with the use of this technology:

H8: Intrinsic motivation has a positive influence on (a) perceived learning and (b) students' satisfaction.
H9: Extrinsic motivation has a positive influence on (a) perceived learning and (b) students' satisfaction.

Finally, students' satisfaction is also influenced by their perceived learning. Findings in different educational contexts have provided empirical evidence for the impact of students' learning performance on their overall level of satisfaction (Tao, Cheng, & Sun, 2009). Students who perceive higher levels of collaborative learning also tend to be more satisfied with their courses (So & Brush, 2008). Therefore, we propose that students' perceived learning as a consequence of using clickers in class will have a positive effect on their satisfaction with the clicker activity:

H10: Perceived learning has a positive influence on students' satisfaction.

4. Methodology

4.1. Data collection and participants

The data was gathered via a survey that was administered to undergraduate business students at a major university in Spain at the end of the semester, in January 2016. Participation in the survey was voluntary and anonymous. A total of 210 questionnaires were completed. Non-valid questionnaires were discarded, resulting in 207 valid questionnaires.

Participants were enrolled in an introductory marketing course during the first semester of the academic year 2015–2016, and they met for two 120-min weekly sessions. Their ages ranged from 18 to 43 ($M = 19.33$, $SD = 2.64$), and 56% were women.

4.2. Procedure

Clicker activities were developed and incorporated in the classes. Specifically, over the course of 15 weeks, students were given seven multiple-choice tests, using clickers to respond. The introductory marketing course included six units. Thus, a total of six tests were administered at the end of each unit, in one of the sessions held in weeks 5, 7, 9, 11, and 14. These multiple-choice tests tried to review and check the students' understanding of the material in each unit. In addition, a final test covering all the material on the course was carried out in week 15. The multiple-choice tests accounted for 20% of the students' final course grade.

Clicker practice activities were undertaken in small groups, comprising four or five students. Therefore, students in each group shared a clicker. At the beginning of each session where a multiple-choice test was administered, groups picked up their assigned clicker. Then, the teacher presented the multiple-choice questions (10 questions per test) using PowerPoint slides and asked the groups to click on the correct answer. Each multiple-choice question had four possible answers, with only one correct response per question. According to the difficulty of the questions, groups were given between 60 and 90 s to discuss among themselves and answer the question using their clicker. The clicker software (Hyper-Interactive Teaching Technology) received the signals from the clickers through a USB receiver connected to a laptop and recorded all responses, which were displayed as a bar graph with the distribution of answers. Then, each group was encouraged to explain its answer to the rest of the class, and discuss alternative answers. Finally, the correct answer was shown.

4.3. Measurement instrument

Well-established scales were employed to measure the constructs included in the model. In all cases, seven-point Likert scale items were used ranging from 1 (strongly disagree) to 7 (strongly agree). Table 1 provides an overview of all the measures. The feedback provided by clickers was measured using items from Jackson and Marsh (1996). Measures of perceived academic control were adapted from Jackson and Marsh (1996) and Perry, Hladkyi, Pekrun, and Pelletier (2001). Value, self-efficacy, and extrinsic motivation were measured using items from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, García, & McKeachie, 1991). The achievement emotions, pride and boredom, were measured using items from the Achievement Emotions Questionnaire (AEQ; Pekrun, Goetz, & Perry, 2005), whereas enjoyment was assessed following Jackson and Marsh (1996). Measures of intrinsic motivation were adapted from the Situational Motivation

Table 1
Constructs, items, and measurement model results.

Constructs, sources and items	λ	CR	AVE
Feedback (Jackson & Marsh, 1996)		0.895	0.741
While I am taking part in the clicker competition…			
FEE1. it is really clear to me that I am doing well.	0.794		
FEE2. I am aware of how many questions I am performing well.	0.890		
FEE3. I know how well I am doing.	0.895		
Perceived academic control (Jackson & Marsh, 1996; Perry et al., 2001)		0.882	0.715
CON1. The greater the effort, the better my performance.	0.811		
CON2. I consider myself responsible for the results of the clicker competition.	0.851		
CON3. I have a high degree of control over my performance on the clicker competition.	0.873		
Self-efficacy (Pintrich et al., 1991)		0.837	0.637
SELF1. I expect to do well.	0.857		
SELF2. I expect to receive an excellent grade.	0.890		
SELF3. I am confident I can learn interesting concepts.	0.619		
Value (Pintrich et al., 1991)		0.941	0.843
VAL1. I think the clicker competition is useful for me to learn the material.	0.914		
VAL2. I think I will be able to use what I have learnt through the clicker competition.	0.915		
VAL3. Understanding the material through the clicker competition is very important to me.	0.924		
Enjoyment (Jackson & Marsh, 1996)		0.950	0.865
ENJ1. I really enjoy the clicker competition.	0.914		
ENJ2. I feel good during the clicker competition.	0.950		
ENJ3. I found the experience with the clickers extremely rewarding.	0.924		
Pride (Pekrun et al., 2005)		0.885	0.721
PRI1. I feel proud if my group does better than other groups.	0.781		
PRI2. I am proud of the contributions I have made in my group.	0.891		
PRI3. When I contribute to my group winning, I get even more motivated.	0.872		
Boredom (Pekrun et al., 2005)		0.856	0.665
BOR1. I find the clicker competition fairly dull.	0.837		
BOR2. When I play the clicker competition I can't wait for the class to end because I feel bored.	0.828		
BOR3. I think about what else I might be doing rather than playing the boring clicker competition.	0.779		
Intrinsic motivation (Guay et al., 2000)		0.897	0.744
INT1. I find the clicker competition funny.	0.840		
INT2. I find the clicker competition interesting.	0.863		
INT3. I find the clicker competition pleasant.	0.883		
Extrinsic motivation (Pintrich et al., 1991)		0.806	0.583
EXT1. Getting a good grade in the clicker competition is the most satisfying thing for me right now.	0.802		
EXT2. I would like to get better grades than the other groups in the clicker competition.	0.668		
EXT3. I want to do well in the clicker competition because it is important to show my ability to my classmates and teachers.	0.812		
Perceived learning (Hamari et al., 2016)		0.928	0.812
PL1. The clicker competition was useful for my learning.	0.891		
PL2. The clicker competition helped me understand the material.	0.893		
PL3. The clicker competition helped me learn.	0.919		
Satisfaction (Kettanurak et al., 2001)		0.903	0.757
SAT1. I found the clicker competition valuable.	0.866		
SAT2. I was very satisfied with the clicker competition.	0.885		
SAT3. I had a very positive learning experience during the clicker competition.	0.859		

Note: λ: Standardized factor loading; CR: Composite reliability; AVE: average variance extracted.

Scale (SIMS; Guay, Vallerand, & Blanchard, 2000). Perceived learning was measured using three items from Hamari, Shernoff, Rowe, Coller, Asbell-Clarke, & Edwards (2016). Finally, satisfaction was assessed following Kettanurak, Ramamurthy, and Haseman (2001).

5. Analyses and results

The hypotheses were tested using partial least squares (PLS) with the software SmartPLS 2.0. Compared to other methods, such as the covariance-based structural equation method, this methodology is appropriate when the interest of the study, as in our case, focuses on prediction and on theory development rather than on strong theory confirmation (Reinartz, Haenlein, & Henseler, 2009). In addition, PLS uses non-parametric procedures and therefore has less restrictive assumptions about the distribution of data. Although PLS estimates both the measurement and structural models simultaneously, this analysis should be evaluated through two steps: analysis of the measurement model and analysis of the structural model.

5.1. Measurement model

First, the reliability and validity of the research constructs were assessed (see Table 1). The results showed that all standardized factor loadings were above 0.7 (Carmines & Zeller, 1979), which suggests that individual item reliability was

adequate. In addition, all the constructs were internally consistent, since their composite reliabilities (CR) were greater than 0.7 (Nunnally & Bernstein, 1994). The constructs also met the convergent validity criteria, as the average variance extracted (AVE) values were above 0.5 (Fornell & Larcker, 1981). Finally, discriminant validity was also supported. In all cases, the AVE for any two constructs was greater than the squared correlation estimate, as shown in Table 2 (Fornell & Larcker, 1981).

5.2. Structural model

To assess the significance of the path coefficients, a bootstrapping procedure with 5000 subsamples was employed. Results of the structural estimation revealed that all the factorial loadings were significant at 1%. The model accounted for 24.7% of the variance in intrinsic motivation, 28.6% in extrinsic motivation, 15.8% in perceived learning, and 47.7% in satisfaction with the gamified activity. The predictive relevance of the model was also assessed through the Stone–Geisser test. The results showed that the Q^2 value of this test for the dependent variables was positive. Therefore, it can be accepted that the dependent variables can be predicted by the independent variables and that the model presents predictive relevance. Table 3 presents the results of the structural model.

The results indicate that feedback provided by clickers was positively associated with perceived academic control ($\beta = 0.43$; $t = 6.58$), self-efficacy ($\beta = 0.42$; $t = 8.55$), and value ($\beta = 0.25$; $t = 3.83$). Thus, H1a, H1b, and H1c were supported.

Regarding the control-value appraisals, perceived academic control was only associated with pride ($\beta = 0.33$; $t = 6.10$), supporting H2b. By contrast, academic control had a non-significant effect on enjoyment ($\beta = 0.03$; $t = 0.51$) and boredom ($\beta = 0.11$; $t = 1.25$). Therefore, H2a and H2c were not supported. Self-efficacy had a positive relationship with pride ($\beta = 0.17$; $t = 1.97$) and a negative relationship with boredom ($\beta = -0.18$; $t = 2.60$), which support H3b and H3c, respectively. The influence of self-efficacy on enjoyment ($\beta = -0.08$; $t = 1.20$) was not statistically significant, leading H3a to be rejected. Finally, as proposed in H4a, H4b, and H4c, value was positively associated with enjoyment ($\beta = 0.48$; $t = 6.85$) and pride ($\beta = 0.19$; $t = 2.58$), and negatively associated with boredom ($\beta = -0.14$; $t = 1.59$), although this relationship was only significant at the 10% level.

Regarding the effect of achievement emotions, the results show that enjoyment experience while using clickers was positively associated with both intrinsic ($\beta = 0.24$; $t = 2.92$) and extrinsic motivation ($\beta = 0.17$; $t = 2.14$), supporting H5a and H5b. The results also indicate that pride was associated with extrinsic motivation ($\beta = 0.43$; $t = 7.00$), which gives support to H6a. However, pride did not exert a significant effect on intrinsic motivation ($\beta = 0.00$; $t = 0.07$), leading H6b to be rejected. Likewise, boredom predicted intrinsic motivation ($\beta = -0.36$; $t = 5.53$), supporting H7a. However, H7b was not supported, as the relationship between boredom and extrinsic motivation was not significant ($\beta = -0.02$; $t = 0.44$).

As expected, both intrinsic ($\beta = 0.23$; $t = 3.64$) and extrinsic motivation ($\beta = 0.30$; $t = 3.91$) were positively associated with perceived learning, providing support for H8a and H9a. Likewise, as proposed in H8b and H9b, intrinsic ($\beta = 0.32$; $t = 5.47$) and extrinsic motivation ($\beta = 0.24$; $t = 2.66$) proved to be significant predictors of satisfaction. Finally, the results reveal a significant positive relationship between perceived learning and satisfaction ($\beta = 0.59$; $t = 6.39$). Therefore, H10 was also supported.

6. Discussion

The popularity of clickers as a way to enhance the learning process has increased during the last few years. Therefore, a large number of studies have analyzed their impact on students' learning outcomes. However, recent literature reviews on clickers have highlighted an important shortcoming of previous research. The existing literature has not integrated theoretical discussions about how clickers affect learning. With the aim of addressing this gap, this study draws on the control-value theory of achievement emotions as a theoretical framework to explain how the use of this technology can improve students' motivation, perceived learning, and satisfaction.

Table 2
Discriminant validity.

	1	2	3	4	5	6	7	8	9	10	11
1. Feedback	**0.74**										
2. Academic control	0.19	**0.71**									
3. Self-efficacy	0.18	0.18	**0.63**								
4. Value	0.07	0.27	0.14	**0.84**							
5. Enjoyment	0.02	0.11	0.08	0.29	**0.86**						
6. Pride	0.21	0.26	0.15	0.19	0.14	**0.72**					
7. Boredom	0.01	0.00	0.04	0.02	0.10	0.01	**0.66**				
8. Intrinsic motivation	0.03	0.00	0.04	0.04	0.13	0.02	0.19	**0.74**			
9. Extrinsic motivation	0.12	0.24	0.12	0.13	0.12	0.26	0.02	0.01	**0.58**		
10. Perceived learning	0.07	0.19	0.15	0.68	0.24	0.11	0.05	0.07	0.11	**0.81**	
11. Satisfaction	0.05	0.12	0.07	0.45	0.53	0.11	0.06	0.13	0.08	0.43	**0.75**

Note: Values on the diagonal are the AVE. Off-diagonal elements are the squared correlations among constructs.

Table 3
Structural results.

	Hypothesis	β	t-value	Supported
H1a	Feedback positively associated with perceived academic control	0.43	6.58***	Yes
H1b	Feedback positively associated with self-efficacy	0.42	8.55***	Yes
H1c	Feedback positively associated with value	0.25	3.83***	Yes
H2a	Perceived academic control positively associated with enjoyment	0.03	0.51	No
H2b	Perceived academic control positively associated with pride	0.33	6.10***	Yes
H2c	Perceived academic control positively associated with boredom	0.11	1.25	No
H3a	Self-efficacy positively associated with enjoyment	0.08	1.20	No
H3b	Self-efficacy positively associated with pride	0.17	1.97**	Yes
H3c	Self-efficacy negatively associated with boredom	−0.18	2.60***	Yes
H4a	Value positively associated with enjoyment	0.48	6.85***	Yes
H4b	Value positively associated with pride	0.19	2.58***	Yes
H4c	Value negatively associated with boredom	−0.14	1.59*	Yes
H5a	Enjoyment positively associated with intrinsic motivation	0.24	2.92***	Yes
H5b	Enjoyment positively associated with extrinsic motivation	0.17	2.14***	Yes
H6a	Pride positively associated with intrinsic motivation	0.00	0.07	No
H6b	Pride positively associated with extrinsic motivation	0.43	7.00***	Yes
H7a	Boredom negatively associated with intrinsic motivation	−0.36	5.53***	Yes
H7b	Boredom negatively associated with extrinsic motivation	−0.02	0.44	No
H8a	Intrinsic motivation positively associated with perceived learning	0.23	3.64***	Yes
H8b	Intrinsic motivation positively associated with satisfaction	0.32	5.47***	Yes
H9a	Extrinsic motivation positively associated with perceived learning	0.30	3.91***	Yes
H9b	Extrinsic motivation positively associated with satisfaction	0.24	2.66***	Yes
H10	Perceived learning positively associated with satisfaction	0.59	6.39***	Yes

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Overall, the results of our empirical study provide strong support for the use of clickers in academic settings as a tool to enhance the learning experience. Our findings reveal that feedback on achievement encourages students' perceived academic control and self-efficacy. Feedback provided by clickers also increases the subjective importance of the activity in which clickers are used. Clickers provide students with instant feedback on their achievement, enabling them to evaluate their level of understanding of the material. If students are aware of their level of performance, they will be more confident and will have a higher degree of control over their future results. In addition, students will believe that the clicker activity is useful for them to learn.

According to the control-value theory, control and value-related appraisals are the main antecedents of achievement emotions. Regarding control appraisals, perceived academic control and self-efficacy positively predicted pride. Therefore, the intensity of this retrospective outcome emotion will be higher when students attribute their success to their abilities or efforts in preparation for the clicker activity. Likewise, self-efficacy correlated negatively with boredom. As such, students' beliefs about their ability to complete the clicker activity successfully will decrease the likelihood of boredom. Interestingly, enjoyment experienced while using clickers was not influenced by the level of perceived academic control or self-efficacy. A reason for this may be that, regardless of perceptions of control (both perceived academic control and self-efficacy), students enjoy the experience of using clickers as it is usually perceived as a funny and appealing activity. Similarly, perceived academic control was not associated with higher levels of boredom. Thus, boredom is induced independently of students' level of perceived academic control. Regarding value appraisals, value was found to have a positive effect on enjoyment and pride, and a negative effect on boredom. This finding confirms that when students perceive the clicker activity to be valuable, they will be more likely to experience positive and activating emotions, such as enjoyment and pride. By contrast, greater value will be associated with lower levels of negative and deactivating emotions, such as boredom.

Our results also show a direct impact of students' achievement emotions on their motivation. On the one hand, enjoyment experienced while using clickers encourages both intrinsic and extrinsic motivation. Likewise, pride positively predicts extrinsic motivation. However, contrary to predictions, pride experienced by students as a consequence of success does not make the clicker activity more intrinsically motivating for them. The fact that the clicker activity accounted for part of the students' final course grade could explain this result. On the other hand, negative emotions, such as boredom, are detrimental for intrinsic motivation. In contrast, we were unable to derive support for the negative relationship between boredom and extrinsic motivation. As noted earlier, one reason for this could be that, regardless of students' perceptions of boredom while using clickers, they may be extrinsically motivated to participate in the competition due to the grades that they receive.

Finally, both students' intrinsic and extrinsic motivation are found to have a positive effect on perceived learning and satisfaction with the clicker activity. Additionally, students who consider the clicker activity to be useful for their learning are more satisfied with the use of this technology.

The current study offers a number of theoretical contributions. Prior studies on clickers have lacked theoretical frameworks in terms of the ways in which clickers influence learning outcomes (Chien et al., 2016; Hunsu et al., 2016). Therefore, this study extends previous clicker research by providing new insights into the effectiveness of this technology, building on the control-value theory of achievement emotions. While prior studies in classroom settings have demonstrated the

importance of emotions for students' learning and achievement (Pekrun et al., 2002, 2009), few papers have investigated this relationship in the context of clicker use (see Stowell & Nelson, 2007 as an exception). An important contribution of this study is, therefore, to empirically analyze the achievement emotions experienced while using clickers, as well as their antecedents and consequences. In addition, our research overcomes limitations of previous clicker studies, such as a bias toward qualitative work, the narrow range of educational settings in which clickers have been explored (e.g., mathematics and science), and the absence of validity and reliability analysis of the measurement instruments (Fies & Marshall, 2006; Kay & LeSage, 2009).

Furthermore, existing research on achievement emotions has primarily investigated students' anxiety, yet only a relatively small number of studies have examined the development and influence of other achievement emotions. Therefore, this research provides insights into the effects of enjoyment, pride, and boredom, and responds to the calls for research to further investigate their effects (Pekrun, 2006; Pekrun et al., 2009; Peterson et al., 2015).

The findings of the present research also have a number of implications for educational practice. The use of clickers evokes different achievement emotions within students. Findings have suggested that positive (negative) emotions experienced by students will result in higher (lower) levels of motivation, perceived learning, and satisfaction. Therefore, instructors that use clickers in their classrooms should pay special attention to the design of the activity in which clickers will be used. Given that students' achievement emotions are influenced by their perceptions of control and value, instructors should highlight the benefits of clicker activities, as well as enhance students' sense of control. Instant feedback on achievement provided by clickers will help to achieve this objective.

There are several limitations to this study, which also suggest directions for further research. First, only students using clickers were investigated. The study took place within a classroom setting. In this context, a control group was not possible as the use of clickers, which were part of the instructional design of the course, was compulsory. Therefore, all students enrolled in the course were required to use them. Using a control group may have also raised some concerns as to whether it may be considered an unfair practice that not all students have access to the educational technology. However, in order to get more insights, future research should use a robust experimental research design that compares users and non-users of clickers.

Second, we acknowledge that the impact of achievement emotions experienced while using clickers on students' motivation, perceived learning, and satisfaction may not be exclusively related to the use of clickers, but also to other factors such as the instructional method based on questioning and peer discussion used in the activity. The instructional design of the activity in which this study was conducted was based on a learner-centered approach in which the focus is on using the technology (i.e., clickers) to aid learners rather than on a technology-centered approach in which the focus is on the technology itself without taking into account human cognition (Mayer, 2001). In this context, previous research suggests that clickers should be implemented with learning strategies that engage students in deeper cognitive processing, such as questioning and peer discussion (e.g., Blasco-Arcas et al., 2013; Brady, Seli, & Rosenthal, 2013; Chien et al., 2016; Mayer et al., 2009; Mazur, 1997; McDonough & Foote, 2015). Therefore, following these suggestions, and with the aim of increasing interactivity and encouraging peer discussion and collaborative learning, the instructional design of the activity combined the use of clickers, questioning and peer-discussion. Overall, building on the control-value theory of achievement emotions, our findings suggest that the use of clickers within this instructional design of the activity can improve students' motivation, perceived learning, and satisfaction. However, while these findings provide new insights into the effectiveness of this technology, we acknowledge that, as noted earlier, the improvement in learning outcomes can be due to both the use of clickers and the instructional method based on questioning and peer discussion. In addition, group dynamics (e.g., clickers might change hands or stay with a designated leader) were not controlled. We suggest future research into clickers explore students reactions not only to shared but also individual clicker activities. For instance, future research could compare the use of clickers by a single individual and their use in groups to analyze to what extent peer group discussions and collaborative learning as a result of using shared clickers, as well as other group dynamics, encourage better learning outcomes. Shared clicker use also involves loss of anonymity in the response and may reduce the level of involvement of some students within the group. Therefore, we advocate further research could also explore whether students' learning outcomes are impacted by these variables.

Third, this study investigated three achievement emotions – enjoyment, pride, and boredom – as they are often experienced by students in academic settings (Pekrun et al., 2002) and are critical for students' learning and motivation. In order to gain a better understanding of emotions experienced by students while using clickers, further research should analyze other emotions, such as shame, anger, or anxiety, as they can also be experienced in academic settings and can affect students' performance.

Fourth, another limitation of this study is the use of self-report measures. Participation in the study was voluntary, and the questionnaire was answered anonymously. To assure anonymity, the survey responses were not linked to students' identities. Therefore, we could not link their responses to objective measures of student performance, such as student grades. Therefore, future research should also include objective measures of students' performance (e.g., student grades) to further explore whether clickers influence students' learning.

Fifth, it is important to highlight the fact that the empirical study is cross-sectional. Information from each respondent was obtained at one point in time. Therefore, we suggest that further research should employ longitudinal designs to provide more insight into probable causation, and facilitate better understanding of the relationships between achievement emotions, their antecedents, and their effects. Specifically, we note that the use of repeated measures of students' emotions at different time points (Ahmed, van der Werf, Kuyper, & Minnaert, 2013) or the use of structured diary methods, in which

participants record their emotions (Peterson et al., 2015) and the reasons why students experience these emotions, would allow a more in-depth analysis of the antecedents and consequences of students' achievement emotions while using clickers.

Despite these limitations, the findings reported in this study contribute to understanding of the influence of clickers on students' motivation, learning, and satisfaction. It is hoped that the conceptual framework drawn from the control-value theory of achievement emotions and the results of the research offer some new insights into the reasons why the use of clickers may facilitate learning outcomes.

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