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Students' perceptions of clickers for enhancing student engagement and academic achievement

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Key Messages

- Students expressed strong positive attitudes toward clickers for engaging and motivating them.
- Students perceive clickers as effective tools for improving academic performance.
- Students are enthusiastic about the use of clickers in an introductory physical geography classroom.

The objective of this research is to summarize students' perceptions on the effectiveness of personal response systems or, more commonly, simply clickers for enhancing their level of engagement and academic achievement. Quantitative and qualitative data were collected from undergraduate university students regarding their perceptions of clickers in an introductory geography classroom. Results suggest a strong link between student engagement and academic achievement, but both engagement and achievement appear invariant to students' perceptions of clickers. Students expressed strong positive attitudes toward the use of clickers, especially their ability to improve the quality of learning experiences and to promote more engaging learning environments.

Keywords: clickers, personal response systems, student engagement, academic achievement, higher education

Introduction

Due to numerous direct and indirect benefits for students, teachers, and society, student engagement should be an important objective for all teachers. The importance of student engagement stems from its direct correlation with several positive student outcomes that include greater academic success (Crosnoe et al. 2004; Trotter 2005; Moredich and Moore 2007; Reyes et al. 2012; Zepke 2014), better health and well-being (Willms 2003; Murray and Zvoch 2011), and lower levels of misbehaviour (Crosnoe et al. 2004; Oelsner et al. 2011). However, student engagement is a complex and multi-dimensional concept (Fredricks and McColskey 2012), which makes it difficult to define (Harris 2008; Taylor and Parsons 2011; Saha 2014) and measure effectively. Student engagement is a function of a student's academic, intellectual, behavioural, social, emotional, cognitive, and psychological connections to their education or school (Harris 2008; Dunleavy and Milton 2009; Willms et al. 2009; Taylor and Parsons 2011; Fredricks and McColskey 2012; Saha 2014). Mostly a function of data availability, many different approaches

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have been used to measure various dimensions of student engagement. Three dimensions of student engagement are used herein: (i) behavioural, which is the dedication or persistence students apply toward participating in their learning; (ii) emotional, which is the emotion or feelings students have toward their learning; and (iii) cognitive, which is the mental strategies, processing, and self regulation skills students use when they are learning.

Unfortunately, however, student engagement can be an especially challenging task in large classes of undergraduate students, who are often reluctant to participate in class (Campbell and Monk 2015; Dong et al. 2017). Paradoxically, student engagement is particularly important in large undergraduate classes because students, especially those at an early stage in higher education, need to quickly engage with the material and their new learning environment. Graduation rates among Canadian undergraduate university students range from a high of almost 90% to a low of 44% at open enrolment universities (Maclean's 2018). This makes student engagement increasingly necessary and simultaneously more difficult, since university class sizes have been steadily increasing over the past 50 years (Huxley et al. 2018). The problems with larger class sizes, particularly as they relate to student engagement, include negative impacts on grades (Kokkelenberg et al. 2008), students' learning experience (Mulryan-Kyne 2010), student-rated outcomes of amount learned, and instructor and course ratings (Monks and Schmidt 2011). Moreover, research suggests that social interactions in the classroom with the teacher and fellow students can enhance student learning (Vygotsky 1978; Mayer and Wittrock 2006). Yet, such interactions, especially teacher-student interactions, are more difficult particularly in large classes.

Correa (1993) argues that many of the problems associated with larger class sizes stem from instructors tending to devote more effort to class-wide activities, such as increased use of lecture-style teaching, at the expense of individual attention. Consequently, there has been increased focus and urgency to find effective tools and techniques to enhance student participation (Campbell and Monk 2015) and to make lectures less passive and impersonal (Burnstein and Lederman 2001). Draper (1998) cautions that technology in the classroom is only worthwhile if it addresses a specific instructional shortcoming, which in this case is the passive, one-way communication that is inherent in lecture-style teaching and the consequent difficulty for students to maintain concentration. This sentiment is echoed by Kirkwood and Price (2005) who argue that it is not simply the introduction of technology that enables student learning, but teachers' pedagogical strategies that are supplemented by the technology.

Personal response systems (PRS), audience responses systems (ARS), student response systems (SRS), learner response systems (LRS), or simply 'clickers' are among the tools and techniques used to enhance student participation, and thereby, student engagement (Blood and Neel 2008; MacGeorge et al. 2008; Strasser 2010; Bachman and Bachman 2011). In fact, Bojinova and Oigara (2011) argue that clickers represent one of the most powerful interactive technologies available for promoting active learning in the classroom. The rationale behind clickers is not new (Caldwell 2007). Teachers have been using the Socratic method of interactive questioning for centuries, but this teaching method becomes progressively more difficult with increasing class size. In addition to the number of students, students in large classes are often reluctant to actively participate in class due to fear of embarrassment or making a mistake (Draper et al. 2002; Caldwell 2007; Bojinova and Oigara 2011; Dong et al. 2017; Katz et al. 2017). In response to these challenges, and in an attempt to foster greater student engagement in the classroom, there is a growing body of literature detailing the implementation and use of clickers in higher education (e.g., Barnett 2006; Caldwell 2007; Koenig 2010; Milner-Bolotin et al. 2010; Strasser 2010; Campbell and Monk 2015). This surge of interest, and of commercial vendors, is based on a mounting body of evidence that demonstrates the ability of clickers to promote an interactive classroom atmosphere (Draper et al. 2002; Roschelle et al. 2004a, 2004b; Johnson and Lillis 2010; Bojinova and Oigara 2011; Simelane and Skhosana 2012).

Clickers are being used increasingly in higher education because they provide a wide variety of potential benefits for both students and teachers alike. Draper et al. (2002) described five pedagogic uses for clickers: (i) formative and summative assessment; (ii) formative feedback for teaching and learning; (iii) peer assessment and community building; (iv) research on human responses; and (v) initiating discussion. These uses are echoed in other studies as well. For example, clickers enable a constructivist approach to learning by providing regular feedback to students during lectures (Barnett 2006; Beatty and Gerace 2009; White et al. 2011). Clickers also provide formative (i.e., diagnostic) assessment which allows teachers to immediately gauge the level of students' understanding of specific concepts (Halloran 1995; Poulis et al. 1998; Draper et al. 2002; Roschelle et al. 2004a; Wood 2004; Beatty and Gerace 2009) and further enables them to adapt lectures to either provide different examples (Mazur 1997; Jones et al. 2012; Lennox Terrion and Aceti 2012), to proceed more quickly, or possibly even eliminate content that students have already mastered (Anderson et al. 2011; White et al. 2011). Other benefits of clickers include higher exam and test scores (Beatty et al. 2006; Poirier and Feldman 2007; Morling et al. 2008; Shaffer and Collura 2009; Shapiro 2009; Shapiro and Gordon 2012; Katz et al. 2017), greater retention of information (Campbell and Mayer 2009; Anderson et al. 2011), more enjoyment of a given course (Barnett 2006; Caldwell 2007), elevated interaction and engagement of students (Jackson and Trees 2003; Blood and Neel 2008; Strasser 2010; Bachman and Bachman 2011; Heaslip et al. 2014; Katz et al. 2017), improved attendance, particularly when clicker responses contribute to participation grades (Burnstein and Lederman 2001; Jackson and Trees 2003; Wit 2003), as well as increased participation by allowing students to anonymously express their understanding of course content (Draper et al. 2002; Wood 2004; Heaslip et al. 2014; Katz et al. 2017), which encourages student risk-taking and lets them know they are not alone in their confusion (Knight and Wood 2005).

Despite a growing body of literature detailing the implementation and potential benefits of clickers in higher education, including several systematic literature reviews (e.g., McDermott and Redish 1999; Roschelle et al. 2004a; Duncan 2005; Fies and Marshall 2006; Caldwell 2007; MacArthur and Jones 2008; Kay and LeSage 2009; Hunsu et al. 2016), much less is known about students' personal experiences using clickers in the classroom (Laxman 2011). Moreover, Kay and LeSage (2009) as well as Barnett (2006) argue there has been a lack of research investigating the implementation and use of clickers in the social sciences, while targeted searches indicate this deficiency certainly applies to the use of clickers in large introductory geography classes. Therefore, the main objective of this research is to summarize undergraduate students' perceptions on the effectiveness of clickers, particularly as a tool to enhance student engagement and academic achievement in an introductory geography class. More specifically, the research aims to answer three questions: (i) do students perceive clickers as effective tools for engaging them; (ii) do students perceive clickers as effective tools for improving their academic performance; and (iii) to what extent do students perceive real value in the use of clickers in the classroom.

What are clickers?

Clickers have been in existence since the 1960s (Judson and Sawada 2002) and generally consist of "a combination of software and hardware that allows students to deliver almost instantaneous feedback to their instructors" (Birdsall 2002, 1). These small wireless handheld devices are commonly referred to as clickers in North America and zappers in the United Kingdom (d'Inverno et al. 2003; Laxman 2011). Modern clickers are used by students to wirelessly transmit their answers (mainly radio-frequency signals), which are automatically collected, tabulated, and summarized by a computer and then displayed in chart form, usually a histogram, but some systems offer more sophisticated options (Roschelle et al. 2004b), such as word clouds for short-answer responses.

The clicker system chosen for this study was the iClicker® (www.iclicker.com), which is touted as the leading SRS in higher education and corporate spaces. The traditional iClicker remote uses a two-way radio frequency (RF), which ensures that there is no interference with Wi-Fi networks. This aspect is an important feature because the iClicker system is a hybrid product, meaning it also operates along with iClicker Cloud 4.3. The iClicker Cloud (formerly REEF Polling and iClicker GO) application is a mobile classroom response system that allows students in the same classroom to use their smartphone, tablet, laptop, or an iClicker remote. iClicker remotes and the iClicker Cloud application enable students to answer three question formats, namely multiple choice, numeric, and short-answer.

Methods

This study received approval from the Brandon University Research Ethics Board (File 21789) on December 4, 2015. The target population for the study was the students enrolled in *Introduction to Physical Geography* (N= 68) at Brandon University during the fall semester of 2015. The sampling frame for the study was all students who attended the last class of the semester on December 7, 2015. These students were provided with a letter of information for implied consent, which described the purpose of the project and their rights as voluntary participants. Students were asked to voluntarily respond to a series of 13 closed-response and two open-response questions that were designed to measure their perceptions on the effectiveness of using clickers in the classroom.

The 15-question survey instrument used in the study was based on a modified version of the instrument used in Sartori's (2008) doctoral dissertation. Survey items were organized into three sections. The first section contained three demographic items, namely sex, year of study, and faculty major. The second section comprised ten items that addressed students' perceptions of using clickers. It employed a five-point Likert scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree) to measure different behavioural, emotional, and cognitive dimensions of student engagement, while recognizing that these dimensions are often intertwined. The third section consisted of two free-response questions: (i) what do you "like most" about using clickers in the classroom; and (ii) what do you "like least" about using clickers in the classroom.

The closed-response questions were displayed on a screen at the front of the classroom and students answered them using their clickers (seven students used RF remotes and 38 used their smartphones). The two free-response survey questions were similarly displayed and students were asked to anonymously write their answers on a piece of loose-leaf paper regarding what they liked most and liked least about using the clickers. Their responses were subsequently transcribed into digital format and then independently categorized by the co-authors with the goal of creating mutually exclusive categories that maintained as much information as possible. The resulting categories and their content were remarkably similar, but a few categories were renamed (for clarity) and others were collapsed into existing categories.

Students' open and closed-responses were merged with objective measures of engagement (i.e., participation grades) and academic achievement (i.e., final grades on tests and assignments). Students' participation grades reflected both attendance and class participation by using the combined score of correct responses to clicker questions, which were worth two points, and incorrect responses that were worth one point and reflected attending class and actively participating. Participation grades were used to measure the emotional and behavioural dimensions of student engagement. Students' final grades reflected the combined score of fact-based and performance-based assessment tools used in the course and were used to measure the cognitive dimension of student engagement, recognizing that dimensions of student engagement often overlap.

Statistical analysis of the closed-response questions and contextual survey questions (i.e., sex, year of study, major) as well as the students' participation and final grades were performed using IBM SPSS version 22. Summary statistics were used to explore the frequency distributions as well as measure central tendency and dispersion of responses. Partial correlations were used to measure the bivariate statistical association between participation (i.e., engagement) and final grade (i.e., achievement) while controlling for both year of study and major. The assumption was that students who are science majors and/or in higher years of study would, *ceteris paribus*, perform better in this introductory science course.

The responses to the first six survey questions (1 to 6) were used to test whether clickers provide an effective tool for increasing the behavioural and emotional dimensions of student engagement and were analyzed against participation grades using Spearman's rank correlation to quantify the strength and significance of statistical associations. The responses to the next three questions (7 to 9) were used to test whether clickers provide an effective tool for enhancing the cognitive dimension of student engagement and were analyzed against measures of students' final grades using Spearman's rank correlation to quantify the strength and significance of statistical associations. The strength of associations is hereafter described as either very weak (0.00–0.19), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79), or very strong (0.80–1.0) based on a guide proposed by Evans (1996). It is noteworthy that despite the implied one-tailed hypotheses associated with these analyses, a more rigorous two-tailed measure of significance was used in the correlation analyses. The last closed-response question (10) plus the two free-response questions were used primarily to investigate the students' perception of value in using clickers in the classroom. Finally, frequency analysis of the open-response questions was used to summarize and communicate what students liked most and liked least about using clickers in the classroom.

Results and discussion

The participants for this study were the 45 undergraduate students who attended the last class of the semester. All of the students responded, which represents a response rate of 100% and a participation rate of 66.2%. The distribution of participants by sex was 22 males and 23 females. The participants represented several different majors; 23 were science majors, 16 were arts majors, five were education majors, and the remaining one reported "NIL" (non-degree credit). There were 14 freshman participants, 12 sophomores, ten juniors, and nine seniors. The response frequencies (in percent) to the closed-response questions are summarized in Table 1.

Responses to the closed-response questions are strongly skewed toward a strong positive perception of using clickers in the classroom (Table 1). Regarding whether clickers provide an effective tool for increasing the behavioural and emotional dimensions of student engagement (questions 1 to 6), the strongest support for clickers relates to their perceived ability to help students "pay attention in class," "gain confidence when correctly responding to the questions," "feeling more involved in the class material," and "contribute positively to my learning." These results accord with the findings of Jackson and Trees (2003), Blood and Neel (2008), Bachman and Bachman (2011), and Strasser (2010) who also found increased interaction and student engagement. Regarding whether clickers provide an effective tool for enhancing the cognitive dimension of student engagement (questions 7 to 9), the strongest support for clickers relates to their perceived benefits "when the teacher discusses the wrong answers as well as the right answers." Other studies have also reported that regular feedback is one of the most appreciated aspects of clickers (Barnett 2006; Beatty and Gerace 2009; White et al. 2011), while Tanner and Allen (2005) explain the value of discussing misinformation, that is, the wrong answers. It is also notable that few students (n = 2) either agreed or were neutral in their belief that "it is a waste of time to use the clickers" while the vast majority (96%) either disagreed or strongly disagreed that clickers are a waste of time. The free-response comments provide further insights into why a few students were less enthusiastic about the use of clickers in the classroom.

The partial correlation coefficients describe the linear relationship between participation grades and final grades while

Table 1
Frequency of student responses

		Percent frequency of student responses				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Behavioural and emotional dimensions of engagement						
1	The clickers helped me pay attention in class	64.4	31.1	4.4	0.0	0.0
2	I feel more involved in the class material when we use clickers	55.6	35.6	8.9	0.0	0.0
3	When I am feeling confused the clicker results help me see that I am not the only person that does not understand	35.6	46.7	17.8	0.0	0.0
4	I enjoy seeing the graphs of the class responses displayed on the screen	35.6	44.4	20.0	0.0	0.0
5	I gain confidence when I correctly respond to the clicker questions	62.2	33.3	4.4	0.0	0.0
6	Because the clickers are used to measure participation, I more regularly attend class than I would if there were no clickers	31.1	37.8	15.6	13.3	2.2
Cognitive dimension of engagement						
7	I find it helpful when the teacher discusses the wrong answers as well as the right answers to the clicker questions	62.2	33.3	4.4	0.0	0.0
8	Clicker questions contribute positively to my learning	57.8	35.6	6.7	0.0	0.0
9	Clicker questions help me process what I just learned	44.4	48.9	4.4	2.2	0.0
Perception of value in the use of clickers						
10	I believe it is a waste of time to use clickers	0.0	2.2	2.2	40.0	55.6

controlling for the effects of year of study and major field of study variables. Based on rank correlation analysis using Kendall's tau-b, both year of study and the students' major field of study are significantly correlated with final grade ($\tau = 0.279$, $p = 0.013$ and $\tau = 0.294$, $p = 0.013$, respectively), while year of study is significantly associated with participation ($\tau = 0.289$, $p = 0.011$). Furthermore, visual inspection of a scattergram, and corroborated by a linear line of best fit ($R^2 = 0.360$), suggests that a linear measure of association appropriately represents the statistical relationship between participation and final grade. The partial correlation coefficient value of 0.567 and two-tailed p-value of <0.001 suggests a moderately strong and statistically significant association between student engagement and student achievement.

Responses to the first six survey questions (1 to 6) were used to test whether clickers provide an effective tool for increasing the behavioural and emotional dimensions of student engagement. Results in Table 2 indicate no statistically significant association between students' participation grade and any of the closed-response survey items. However, there are some associations among the closed-response survey questions themselves, which point toward the overlapping nature of behavioural, emotional, and cognitive dimensions of student engagement and the difficulty in disentangling them. For example, and not surprisingly, students who feel strongly that the clickers help them "pay attention in class" also reported that clickers (a) make them "feel more involved in the class material" ($\rho = 0.539$, $p = <0.001$), (b) help them see that they are "not the only person that does not understand" ($\rho = 0.313$, $p = 0.036$), and (c) help them "gain confidence when they correctly respond to the clicker questions" ($\rho = 0.604$, $p = <0.001$). Also, students who felt more involved in the class material tended to report "gaining confidence when they correctly respond to the clicker questions" ($\rho = 0.329$, $p = 0.028$) and they "more regularly attend class than they would if there were no clickers" ($\rho = 0.307$, $p = 0.040$). In fact, many others have found increased attendance when clicker responses contribute to participation grades (Burnstein and Lederman 2001; Jackson and Trees 2003; Wit 2003). Students who more strongly agree with the statement that they "enjoy seeing the graphs" are also more likely to feel strongly that the clicker "helps them see that I am not the only person that does not understand" ($\rho = 0.296$, $p = 0.048$) and "gain confidence when they correctly respond to the clicker questions" ($\rho = 0.325$, $p = 0.029$). Finally, students who feel strongly that the clickers "help them see that I am not the only person that does not understand" also report strong feelings of "gaining confidence when they correctly respond to the clicker questions" ($\rho = 0.357$, $p = 0.016$). This weak relationship suggests the two survey items are measuring similar yet, at the same time, different dimensions of student engagement.

The next three survey questions (7 to 9) were used to test whether clickers provide an effective tool for enhancing the cognitive dimension of student engagement. Results in Table 3 indicate there is no statistically significant association between academic achievement and any of the corresponding closed-response survey items. While it was hypothesised that there would be significant associations among the three closed-response questions, there is only one significant association between clicker questions, namely "contributing positively to my learning" and "helping me process what I just learned" ($\rho = 0.373$, $p = 0.012$). This weak relationship highlights the difficulties in disentangling the different dimensions of student engagement.

The final survey question (10) was used to investigate whether students perceive real value from the use of clickers in the classroom. While 55% of students strongly disagreed with the statement "it is a waste of time to use the clickers," another 40% disagreed, one student remained neutral, and another student agreed. These results suggest almost all students perceive real value in using clickers in the classroom.

The free-response questions garnered a wide variety of responses that provide further insights into what students liked most and least about using clickers. Allowing students' responses to include multiple 'meanings' and, thus be counted in multiple categories, text classification of the 45 students' comments regarding what they liked most about clickers yielded a total of 83 sentiments that were classified into ten mutually exclusive

Table 2
Spearman's rank correlation (ρ) of participation and engagement questions

	Participation grade	Q 1 Pay attention	Q 2 Feel more involved	Q 3 Enjoy seeing graphs	Q 4 Not feeling alone	Q 5 Gain confidence	Q 6 More regularly attend
Participation grade	1	-0.217	-0.192	-0.170	0.094	-0.077	-0.022
Sig. (2-tailed)	-	*0.151*	*0.206*	*0.264*	*0.538*	*0.617*	*0.886*
Q 1 Pay attention	-0.217	1	0.539	0.192	0.313	0.604	0.288
Sig. (2-tailed)	*0.151*	-	*<0.001*	*0.206*	*0.036*	*<0.001*	*0.055*
Q 2 Feel more involved	-0.192	0.539	1	0.236	0.219	0.329	0.307
Sig. (2-tailed)	*0.206*	*<0.001*	-	*0.118*	*0.149*	*0.028*	*0.040*
Q 3 Enjoy seeing graphs	-0.170	0.192	0.236	1	0.296	0.325	-0.273
Sig. (2-tailed)	*0.264*	*0.206*	*0.118*	-	*0.048*	*0.029*	*0.070*
Q 4 Not feeling alone	0.094	0.313	0.219	0.296	1	0.357	-0.212
Sig. (2-tailed)	*0.538*	*0.036*	*0.149*	*0.048*	-	*0.016*	*0.161*
Q 5 Gain confidence	-0.077	0.604	0.329	0.325	0.357	1	0.207
Sig. (2-tailed)	*0.617*	*<0.001*	*0.028*	*0.029*	*0.016*	-	*0.173*
Q 6 More regularly attend	-0.022	0.288	0.307	-0.273	-0.212	0.207	1
Sig. (2-tailed)	*0.886*	*0.055*	*0.040*	*0.070*	*0.161*	*0.173*	-

Table 3
Spearman's rank correlation (ρ) of final grades and achievement questions

	Final grade	Q 7 Helps to discuss wrong answers	Q 8 Contribute to learning	Q 9 Help me process what I learn
Final grade	1	-0.006	0.006	-0.146
Sig. (2-tailed)	-	*0.969*	*0.968*	*0.339*
Q 7 Helps to discuss wrong answers	-0.006	1	0.275	0.249
Sig. (2-tailed)	*0.969*	-	*0.067*	*0.099*
Q 8 Contribute to learning	0.006	0.275	1	0.373
Sig. (2-tailed)	*0.968*	*0.067*	-	*0.012*
Q 9 Help me process what I learn	-0.146	0.249	0.373	1
Sig. (2-tailed)	*0.339*	*0.099*	*0.012*	-

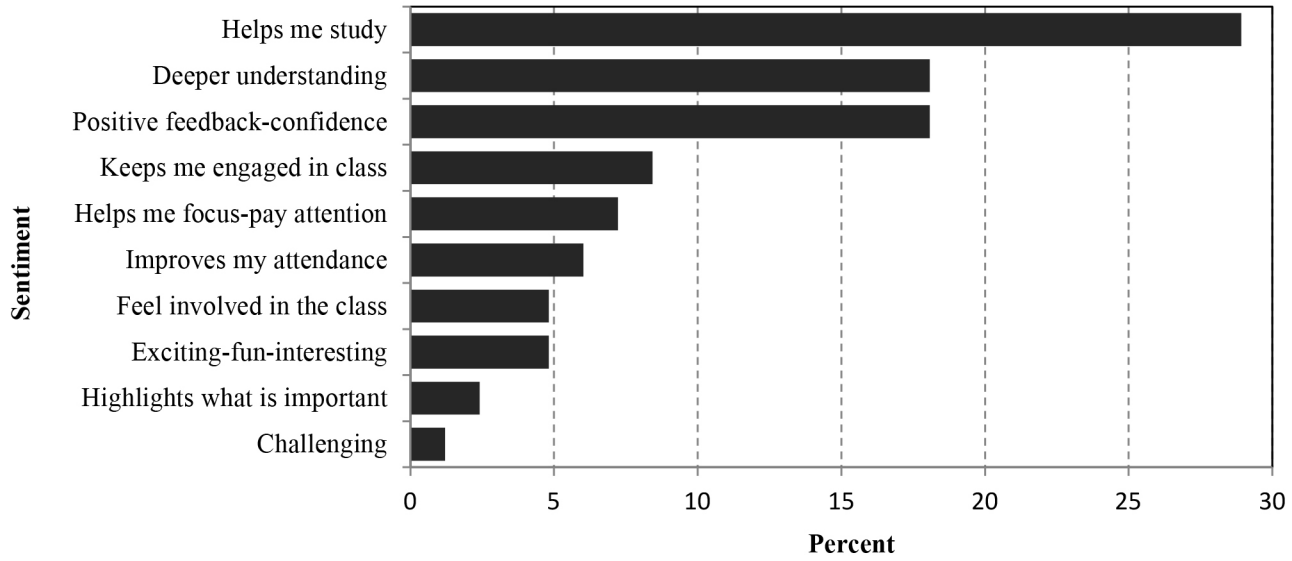

Figure 1
Open, responses to what students "liked most" about using clickers

categories. A similar process, however, yielded only 54 sentiments about what they liked least. These were classified into 12 mutually exclusive categories. The frequency distribution of sentiments about what students liked most is illustrated in Figure 1, while the frequency distribution of sentiments about what students liked least is illustrated in Figure 2.

The modal response regarding what students liked most about the clickers is that they "helped them study for exams," which represents almost one-third (28.9%) of all sentiments, and it was reported by more than half of the respondents. Similar findings have been widely reported in other studies (Beatty et al. 2006; Poirier and Feldman 2007; Morling et al. 2008; Shaffer and Collura 2009; Shapiro 2009; Shapiro and Gordon 2012). This response is directly influenced by the iClicker Cloud software, which saves a screen capture of the questions. Students are then able to review all the questions asked during each session, thus providing a great study guide for any student who uses the iClicker Cloud application on their mobile device. This option is not available to students who use the iClicker remote, but the questions were made available to those students in pdf format. The next two most common sentiments relate to clickers providing a "deeper understanding" of the material and the "positive feedback increasing their confidence" (both at 18.1%). Campbell and Mayer (2009), Milner-Bolotin et al. (2010), as well as Anderson et al. (2011) also indicated students reported greater retention of information. The belief that clickers provide a deeper understanding stems from the instructor reviewing not only an explanation of the correct answer, but also an explanation of why the other answers are incorrect. The positive feedback provided by answering correctly confirms the student's understanding and gives them confidence.

The next two responses in Figure 1 are related, but sufficiently different to be categorized separately. Responses suggest that the clickers help students "focus or pay attention" during the lecture (7.2%) and they indicate that students are kept "more engaged in class" (4.8%), likely because students know they will be asked to answer clicker questions related to the lecture topic. Similarly, responses indicate that students "feel more involved in the class" and suggest the atmosphere created by the clicker is "fun, exciting, and interesting." The enhanced two-way interaction and level of excitement generated by using clickers in the classroom has been widely reported by others (Laurillard 1993; Draper et al. 2002; Roschelle et al. 2004a, 2004b; Johnson and Lillis 2010; Bojinova and Oigara 2011; Simelane and Skhosana 2012). Other sentiments indicate that clickers lead to "improved attendance," presumably because students know their attendance is part of their final grade; a finding also reported by Draper et al. (2002) and Wood (2004). While similar attendance rates were reported by Burnstein and Lederman (2001) who reported 80 to 90% attendance in science classes where clickers were used, the class surveyed for this study averaged over 70% attendance for the semester. Students' sentiments corroborate the argument that clickers enhance the behavioural dimension of student engagement.

Comprising 22% of all sentiments, and reported by more then one-quarter of respondents, the modal response regarding what students liked least about the clickers was "the cost." On the one hand, this response is surprising given the cost of the iClicker Cloud application is only $10 and a used iClicker remote is about $25. On the other hand, if this is the most significant criticism of the clicker system, then it can be concluded that students have only minor negative perceptions about using clickers in the classroom. This is confirmed by one of the two second-most frequently reported concerns; 19% of sentiments indicate there was "nothing" that the students disliked about using clickers in the classroom. The other second-most frequently reported negative sentiment relates to the frequent dropping of the Wi-Fi signal in the lecture theatre, which necessitated restart-

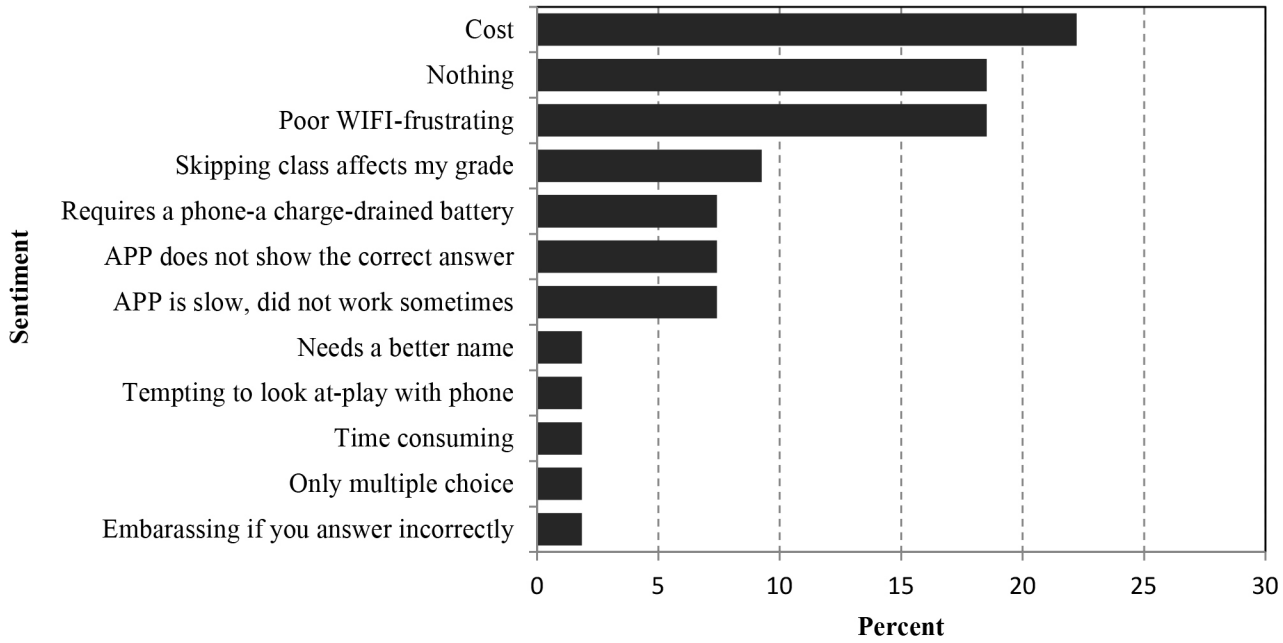

Figure 2
Open, responses to what students "liked least" about using clickers

ing the program and caused a considerable amount of frustration for many users of smart-device applications, but not the iClicker remote users. Again, this was not a criticism of the clicker itself, but rather the associated classroom infrastructure. Reports of clickers not always working properly are described in detail by Barnett (2006) while potential implementation problems are described by Hoekstra and Mollborn (2012). The third-most frequently reported concern surrounds students being disappointed that skipping class would affect their participation grade, a concern that was echoed when clickers were used only for attendance (Trees and Jackson 2007). This revelation may indicate that grade-oriented students may be more engaged by the participation grade than the use of clickers, which raises issues of disentangling the impact of clickers alone on either engagement or achievement. The next three most frequently reported concerns relate to the smart-device application, which drains the battery on their smartphone, was sometimes slow (presumably related to Wi-Fi issues), and the application did not record the correct answer (only a screen grab of the question, which was an intentional aspect of course design). There were four other individual responses that suggested the application might deserve a better name, using their phone in class tempted them to check their social media accounts, it was embarrassing to find out they were the only person to answer incorrectly, and perhaps the professor relied too heavily on multiple choice responses.

Overall, students' perceptions on the effectiveness of clickers to enhance student engagement and academic achievement appear overwhelmingly positive, which accords with previous findings. Students' perceptions also provide valuable insights into the perceived strengths and weaknesses of using clickers, which are particularly relevant to teaching large undergraduate classes. Large classes arguably provide the best forum for the pedagogical benefits of clickers, because the anonymity that clickers provide empowers all students to have a 'voice' (Giroux and McLaren 1986, 233) in the classroom without the fear of embarrassment or making a mistake, and by letting them know they are not alone in their confusion. Professors are also empowered by using clickers in the classroom, because the technology can be used to enhance their pedagogical strategies, such as promoting an interactive classroom atmosphere, and providing real-time feedback, which allows them to immediately gauge the level of students' understanding and then adapt the content and pace of instruction to reflect their students' needs. On this basis, and despite the possibility of operational issues as noted above, professors should be encouraged rather than dissuaded to adopt clickers in their classrooms.

This research has its limitations. For example, the cross-sectional nature of the sample raises attendant concerns over representativeness and generalizability, while the self-selection of students attending the last day of class raises concerns over potential biases, such as social desirability bias, especially within the power relations and semester-long positive relationship between the professor and the students. Another important limitation is the observed lack of a clear statistical association between the perceived benefits of using clickers and either the behavioural and emotional dimensions (participation) or the cognitive dimension (achievement) of student engagement. This may be due, for example, to the relatively small sample size for the study, the highly skewed opinions on the perceived benefits of clickers, the absence of an empirical relationship, or the manifest variables (i.e., participation grades and final grades) may not be good proxies for student engagement and academic

achievement, respectively. Another consideration is that participation, and particularly as a measure for the behavioural dimension, may have been too narrowly defined in the study (attending class and correctly answering clicker questions). Appleton et al. (2006) suggest participation should include attendance, class participation, time spent on homework, and involvement in extra-curricular activities. Future research should employ a more nuanced measure of student engagement, and potentially academic achievement (perhaps according to fact-based and performance-based assessment items) to better understand the impact of clickers on different dimensions of student engagement. Rather than attempting to disentangle the multi-dimensional nature of student engagement, an alternate approach, perhaps using data reduction techniques such as principal component analysis, could capitalize on the overlapping nature of student engagement dimensions, but then this would raise issues of cumulative effects.

Conclusion

Student engagement is an important goal for higher education, because there is a strong direct link between student engagement and several positive outcomes, including academic achievement. This research aimed to answer three questions, namely if students' perceptions provide convincing evidence that clickers: (i) are effective tools for engaging and motivating them inside and outside the classroom; (ii) are effective tools for improving academic performance; and (iii) provide real value in an introductory physical geography classroom. The results of this study demonstrate a significant association between student engagement and academic achievement. However, the results fail to demonstrate a statistical association between the students' perceptions on the effectiveness of clickers and measures of either student engagement or academic achievement. This research suggests that students believe clickers can help create an interactive, adaptive, and flexible learning environment that has the potential to enhance student engagement.

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