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The Effect of Performance Feedback on Student Help-Seeking and Learning Strategy Use: Do Clickers Make a Difference?

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The Effect of Performance Feedback on Student Help-Seeking and Learning Strategy Use: Do Clickers Make a Difference?

Abstract

Two studies were performed to investigate the impact of students' clicker performance feedback on their help-seeking behaviour and use of other learning strategies. In study 1, we investigated the relationship between students' clicker performance, self-efficacy, help-seeking behavior, and academic achievement. We found that there was a significant positive correlation between their clicker performance and their course grades, and help-seeking behavior was negatively and significantly related to clicker and course performance but only for participants with high self-efficacy. In study 2, we expanded our focus to determine if participants modified a number of learning strategies as a result of receiving clicker performance feedback as well as attempting to replicate the clicker-course performance relationship found in study 1. Although participants reported an increase in their use of various learning strategies as a result of using the clickers, changes in learning strategy use was not significantly related to clicker or term test performance. The relationship between clicker and course performance was replicated. The results suggest that clicker-based feedback alone may not be sufficient to lead to a successful change in learning strategy use and that students may need more specific instruction on self-regulation and effective learning strategy use in order to improve their learning.

Deux études ont évalué l'impact de la rétroaction sur la performance des étudiants indiquée par télévoteur sur leur comportement de recherche d'aide et sur les autres stratégies d'apprentissage utilisées. Dans la première étude, les chercheurs se sont penchés sur la relation entre la performance indiquée par télévoteur, le sentiment d'auto-efficacité, la recherche d'aide et la réussite scolaire. Nous avons trouvé une corrélation positive significative entre la performance indiquée par télévoteur et les notes de cours. De plus, nous avons également découvert un lien négatif significatif entre le comportement en matière de recherche d'aide, le télévoteur et la performance dans le cours, mais uniquement chez les participants ayant un sentiment d'auto-efficacité élevé. Dans la deuxième étude, nous avons élargi notre approche pour déterminer si les participants avaient modifié plusieurs stratégies d'apprentissage après avoir obtenu une rétroaction sur leur performance par télévoteur. Nous avons de plus tenté de répliquer la relation entre le télévoteur et la performance dans cours découverte lors de la première étude. Bien que les participants aient déclaré avoir utilisé davantage de stratégies d'apprentissage après avoir utilisé le télévoteur, nous n'avons pas trouvé de lien significatif entre les changements relatifs à ces stratégies et le télévoteur ou le test de performance de mi-semestre. Nous avons répliqué le lien entre le télévoteur et la performance dans le cours. Les résultats suggèrent que la rétroaction offerte par le télévoteur n'est pas suffisante en soi pour entraîner un changement fructueux en matière de stratégies d'apprentissage et que les étudiants ont besoin d'instructions plus spécifiques sur l'autorégulation et sur les stratégies d'apprentissage efficaces pour mieux apprendre.

Keywords

clickers, active learning, learning strategies, help-seeking, academic achievement

Cover Page Footnote

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Clickers have recently been adopted for use in many large university classrooms across Canada, the United States, and the United Kingdom (Carnaghan & Webb, 2005; Nicol & Boyle, 2003). With clickers, students respond via hand-held devices to multiple-choice or true/false questions presented by the instructor. The students' responses are transmitted by radio frequency to the classroom computer, where their aggregated responses can be revealed to the class. Clickers provide a mechanism for an instructor to receive immediate feedback on learning from hundreds of students at once and, more importantly, for students to receive feedback on their understanding of the course material (Barnett, 2006).

The distributors of these devices claim that use of the technology leads to greater student engagement and therefore greater classroom learning (Barnett, 2006; Carnaghan & Webb, 2005). Both students and faculty report that the experience of using clickers in the classroom is very positive and leads to increased classroom satisfaction (e.g., Addison, Wright, & Milner, 2009; Davis, 2003; Judson & Sawada, 2002; Kaleta & Joosten, 2007; Morin, Thomas, Barrington, Dyer, & Boutchkova, 2009). Clicker use also may increase the use of engaged pedagogies in large classes by enabling widespread anonymous participation (Caldwell, 2007; Morin et al., 2009; Rhem, 2009), providing immediate feedback, and/or creating a cumulative record of participation (Beatty, 2004). One of the critical elements and most commonly cited benefits of clickers is the immediate feedback students receive about their understanding of the course material (Barnett, 2006). However, little is known about how students respond to that feedback. Do they alter their learning strategies to improve their understanding of the course material? If so, how?

We performed two studies to examine these questions more fully. The first concentrated on one learning strategy, students' help-seeking behaviour, whereas the second focused on a range of learning strategies.

Study 1

This study had several objectives. First, we wanted to determine the relationship between students' clicker performance and their course grades, in order to determine the diagnostic value of clicker performance in academic performance. We hypothesized that there would be a positive relationship between students' clicker responses and their grades in the course and that the relationship would be evident when participants' past academic performance, clicker participation (i.e., how often they responded to clicker questions), learning efficacy, and sex were controlled for. This was done to demonstrate that clicker performance is related to course performance and that the relationship is not simply a by-product of the other variables. We also wanted to demonstrate that students' clicker responses represent an effort to answer questions correctly, rather than arbitrarily pressing buttons to receive a participation grade, as has been suggested by some who question the pedagogical utility of clickers.

Second, we wanted to explore the relationship between students' clicker performance and their help-seeking behaviour. One assumption that underlies the use of clickers is that upon receiving performance feedback, students will seek help if they see that their comprehension of a topic has failed (Bruff, 2009). Yet, to our knowledge, no research has investigated whether or not this is true.

We anticipated that the clicker performance–help-seeking relationship would be moderated by the students' sense of self-efficacy—their beliefs about their own ability to achieve goals (Svinicki, 2004). Although students may have a general sense of self-efficacy about their ability to learn in university, they may also have a sense of self-efficacy that is task specific (Svinicki, 2004), which is why we examined students' sense of self-efficacy in introductory biology specifically. Researchers have suggested that students who do not believe they are capable of completing a task, those with low self-efficacy, are less likely to engage in self-regulated activities such as seeking help and less likely to persist at tasks (Pintrich & de Groot, 1990). For students with low levels of self-efficacy, we did not expect that their clicker use would lead them to seek help even if needed.

Locus of control was another individual difference variable we examined. Students who have an internal locus of control believe that success on tasks is influenced by effort, motivation, and ability (Findley & Cooper, 1983). In the face of failure, they will critically examine what they need to do to improve their performance the next time, including potentially seeking help. Those with an external locus of control attribute performance to luck, timing, or other variables over which they have no control and thus are not motivated to make changes in their learning strategies, such as help seeking, in the face of failure.

Consistent with research by Karabenick and Knapp (1991), we also predicted that when students do seek help, it would be from informal rather than formal sources (e.g., friends rather than the instructor), even though it is likely that the formal sources would be better equipped to provide effective assistance.

Finally, we investigated participants' attitudes towards the use of clickers in class and their relation to clicker and academic performance. A number of researchers (e.g., Davis, 2003; Judson & Sawada, 2002; Kaleta & Joosten, 2007) have found that students react positively to clicker use and we wanted to determine if their attitudes were related to how well they perform in answering clicker questions or in the course. Based on our experience with clickers, we predicted that students, regardless of their clicker or course performance, would be positive about their use.

Method

Participants. Three-hundred and twenty-four students (234 women) enrolled in a full-year introductory biology course at a large medical doctoral university in Canada participated in the study, representing a 27% response rate. The majority of participants were in the first year of their academic programs (96%) and in the Faculty of Science (68%), with a sizable minority in the Faculty of Health Sciences (26%).

Measures. Participants completed a 21-item survey. Of the 21 items, 18 were developed by the researchers for this study. The three remaining items were multifaceted and taken from standardized measures. All of the items are addressed below.

Demographic items. Four items assessed participants' sex, program year, faculty, and use of clickers in other courses.

Help-seeking behaviour. Participants' help-seeking behaviour was assessed using two measures. They completed the Help-Seeking scale of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1993), indicating, on a 5-point scale (0 = *not at all true of me*, 4 = *very true of me*), the extent to which they seek help from their peers or instructors. Cronbach's alpha, which measures the degree of internal consistency amongst items on a scale (Cronbach, 1951), was .63 for the 3-item version used in the current study.

Participants also indicated, on a 5-point scale (0 = *never* to 4 = *all the time*), how often they had accessed 11 different sources of help since the beginning of the academic year. Specifically, they were asked to rate how often they turned to a teaching assistant (TA), the course instructor, their parents, their friends, the Internet, study groups for the course, the library, campus-based learning skills services, residence staff, and sophs (upper-year students) for residence- and nonresidence-based students. The participants' ratings on help-seeking resources were subject to a principal components analysis to determine their factor structure. One factor (Cronbach's alpha = .75), referred to here as the Helping Resources factor, was extracted. The MSLQ Help-Seeking subscale and the Helping Resources factor were significantly correlated ($r = .40$, $p < .001$).

Self-efficacy. Participants completed the eight-item Self-Efficacy scale of the MSLQ (Pintrich et al., 1993), which is designed to determine participants' judgment of their ability to perform a task. Participants indicated, on a 5-point scale (0 = *not at all true of me*, 4 = *very true of me*), their self-efficacy in their introductory biology course. The MSLQ has been found to be a reliable and valid measure of learning strategies (see Pintrich et al., 1993, for a review). For the current investigation, Cronbach's alpha for the scale was .95.

Locus of control. Participants' academic locus of control was assessed with a 13-item version of the Academic Locus of Control scale (Trice, 1985). Trice (1985) provides information on the reliability and validity of the original 28-item true/false version of the scale. In the current study, participants rated each item on a 5-point scale (0 = *not at all true* to 4 = *very true*). Six of the 13 items were worded to reflect an external locus of control and five were worded to reflect an internal locus. For all analyses, the five internal items were recoded to reflect an external locus of control. Cronbach's alpha for the 13-item version was .68.

Academic achievement. Participants were asked to give researchers permission to access their admission average (i.e., their high school average used as the basis for their admission to the university), test and final course grades in introductory biology, and clicker responses. Permission was received from 80% to access their admission average, 69% for course grades,[1] and 75% for clicker responses, respectively. Clicker performance was calculated by dividing an individual participant's number of correct responses by the total number of questions answered. The overall mean clicker performance for this study was .47 (SD = .11).

Perceptions of clickers. Participants completed six items assessing their perceptions of the effect of the clickers on various characteristics. They rated the extent to which they perceived that the clickers affected their learning of the course material, enthusiasm for the course, course attendance, attention in class, and interest in taking further courses in biology. Participants also rated their feelings about the clickers. All of the ratings were on a 5-point scale, with higher ratings indicating greater perceived learning, greater enthusiasm, etc.

Procedure. Students enrolled in two sections of a full-year introductory biology course used clickers in their classes. Both sections were taught by the same three instructors, in series. All three instructors used clickers in their classes. The number of questions asked ranged from one to six, depending on the class. The types of questions asked varied from factual to conceptual and were used to assess both prior knowledge and current understanding of concepts. Participation, in the form of responding to at least 80% of clicker questions, was worth 5% of the course grade.

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[1] Participants in Study 1 scored approximately 4% higher on three term tests and the final examination than the classes overall. This difference will be addressed in the General Discussion of the paper.

Seventeen weeks into the course, students received an e-mail invitation to participate in an online survey. A reminder was sent one week later. Interested participants clicked on a hyperlink in the e-mail to access the survey. To be entered into a draw for one of three Apple iPod Shuffles (or gift certificates of equivalent value), participants were required to input their student number at the end of the survey. Upon completing the survey, participants clicked on a button to submit their responses. Submission of the survey was taken to indicate consent to participate.

Results

The first objective of the study was to establish the relationship between students' clicker performance and their course grades, and a significant correlation was in fact found between the two variables ($r = .63$, $p < .001$). A hierarchical multiple regression was performed to examine the clicker performance–grades relationship, partialling out students' admission average, learning self-efficacy, science self-efficacy, sex, and clicker participation (i.e., number of clicker questions answered). Even partialling out these variables, the clicker performance–grade relationship was significant (see Table 1).

Table 1
Correlations Between Predictors and Final Grade

Predictors	Zero-order correlation	Partial correlation	*t* test
Admission average	.58*	.34	4.78*
Self-efficacy	.62*	.37	5.21*
Science efficacy	.41*	-.01	-.11
Sex	-.19	-.04	-.58
Clicker participation	.35*	.29	4.01*
Clicker performance	.65*	.47	7.00*

Note. The partial correlations presented are those after all of the predictors have been entered into the equation in the order presented in the table (i.e., clicker performance last).
*$p < .001$.

The second objective of the research was to explore the relationship between participants' help seeking, clicker performance, and academic performance. Clicker performance was not significantly related to either the Helping Resource variable ($r = -.08$, *ns*) or the MSLQ Help-Seeking subscale ($r = -.01$, *ns*), nor were course grades ($r = -.12$, *ns* and $r = -.01$, *ns*, respectively).

To determine if self-efficacy moderated the help-seeking–clicker performance and help-seeking–grade relationships, we performed a tertile split on participants' self-efficacy scores and examined the correlations separately. Based on the tertile split, participants with low self-efficacy had a score of 2.12 or less, and those with high self-efficacy had a score of 3.01 or greater (on a scale from 0 to 4).

For participants with low self-efficacy, the correlations between help seeking and clicker performance were not significant ($r = .11$, *ns*, for Helping Resources and $r = .12$, *ns*, for the MSLQ Help-Seeking subscale). On the other hand, for participants with high self-efficacy, there was a small but significant correlation between clicker performance and Helping Resources ($r =$ -

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.27, $p < .05$), but not the MSLQ Help-Seeking subscale ($r = -.17$, *ns*). We performed a Fisher *r*-to-*z* transformation to determine if the Helping Resources–clicker performance correlations were significantly different between participants with low and high self-efficacy. The correlation for participants with high self-efficacy was significantly larger than that of their low self-efficacy counterparts ($z = 2.28$, $p < .05$).

A similar pattern of results was evident with the help-seeking–course grade relationship. For participants with low self-efficacy, the correlations were not significant ($r = .19$, *ns*, for Helping Resources and $r = .03$, *ns*, for the MSLQ Help-Seeking subscale). On the other hand, participants with high self-efficacy had significant and negative correlations between grades and Helping Resources ($r = -.38$, $p < .001$) and the MSLQ Help-Seeking subscale ($r = -.41$, $p < .001$). We performed Fisher *r*-to-*z* transformations to determine if the help-seeking–clicker performance correlations were significantly different between participants with low and high self-efficacy. The correlation for participants with high self-efficacy was significantly larger than that of their low self-efficacy counterparts for both Helping Resources ($z = -2.34$, $p < .01$) and the MSLQ Help-Seeking subscale ($z = -3.43$, $p < .001$).

We also examined self-efficacy differences in where participants sought help. Participants with high self-efficacy were more likely to seek help from their instructor than were their low self-efficacy counterparts [$t(181) = -3.27$, $p < .005$; $M = 1.17$, $SD = 1.10$ and $M = .75$, $SD = .71$, respectively]. Participants with low self-efficacy were more likely to seek help from the library than were their high self-efficacy counterparts [$t(181) = 3.61$, $p < .001$; $M = 1.81$, $SD = 1.42$ and $M = 1.10$, $SD = 1.38$, respectively]. There were no significant self-efficacy differences for the other nine individual helping resources.

To determine if locus of control moderated the help-seeking–clicker performance and help-seeking–course grades relationships, we performed a tertile split on participants' locus of control scores and examined the correlations separately. Based on the tertile split, participants with an internal locus of control had a score of 1.31 or less, and those with an external locus of control had a score of 1.85 or greater (on a scale from 0 to 4). For participants with an internal locus of control, the correlations between help seeking and clicker performance were not significant ($r = -.15$ and -.16, *ns*, for Helping Resources and the MSLQ Help-Seeking subscale, respectively) nor were they significant for participants with an external locus of control ($r = .03$ and .09, *ns*, for Helping Resources and the MSLQ Help-Seeking subscale, respectively). Similarly, for participants with an internal locus of control, the correlations between help seeking and course grades were not significant ($r = -.21$, *ns*, for Helping Resources and $r = -.04$, *ns*, for the MSLQ Help-Seeking subscale), nor were they significant for participants with an external locus of control ($r = .24$ and .20, *ns*, respectively).

As can be seen in Table 2, when participants sought help, they sought it from their friends significantly more often than any other resources [e.g., more than the Internet, $t(322) = 11.38$, $p < .001$, or the biology TA, $t(322) = 20.83$, $p < .001$]; in other words, they were more likely to seek help from informal rather than formal sources. It is noteworthy that participants were almost equally likely to seek help from their parents and the course instructor [$t(323) = 1.72$, *ns*].

Table 2
Resources Students Accessed for Help

Resource	*M*	*SD*
Friends	3.13	.98
Internet	2.32	1.18
Biology TA	1.62	1.15
Biology study groups	1.57	1.46
Library	1.44	1.45
Parents	1.15	1.29
Biology instructor	.99	.99
Sophs (upper-year students)	.89	1.18
Residence staff	.77	1.14
Learning skills services	.57	.95
Office-campus dons (peer mentors)	.23	.66

The third objective was to examine participants' perceptions of the clickers and their perceptions' relationship with clicker and course performance. Overall, participants were very positive about using clickers in the classroom. Specifically, 89% of participants indicated that they were moderately or extremely positive about the use of clickers and 86% felt that the clickers somewhat or greatly facilitated their learning of the course material. A majority of students also felt that the clickers somewhat or greatly increased their enthusiasm for the course (65%), attention in class (62%), and attendance (60%). Even though students' perceptions of clickers were positive, a majority indicated that clicker use had no effect on their interest in pursuing further education in the biological sciences (78%). Participants' attitudes towards the clickers were not related to their clicker performance (r ranged from -.12 to .15, *ns*) or their final course grade (r from -.14 to .16, *ns*).

Discussion

As predicted, there was a significant correlation between participants' grades and their clicker performance, which was maintained when we partialled out past academic achievement, self-efficacy, sex, and clicker participation. Thus, clicker performance has diagnostic value for students' performance on their exams, over and above the variables outlined above (i.e., the relationship is not simply a product of those variables). This is a particularly important finding, as instructors can advise their students with confidence of the clicker performance–course grade relationship and recommend, if they are not doing well on the clicker questions, that they may need to make adjustments to their studying to ensure that they perform well on tests. Also the correlation suggests that students were not just arbitrarily pressing buttons to receive the participation grade, but were making a serious effort to answer the questions correctly. For instructors, this is important, as some may incorrectly believe their students are responding arbitrarily.

The diagnostic value of students' clicker performance is, of course, influenced by the degree of congruence of clicker questions with test questions. Clicker questions and test questions used in the classes under investigation were generally very similar in their multiple-choice structure and content focus.

Contrary to prediction, there was no overall significant relationship between help seeking and clicker performance. However, we did find that a small but significant negative relationship does exist for participants with high, but not low, self-efficacy. Students who felt that they could do well in the course tended to seek help if they were not doing well on the clicker questions. Like all the participants, they tended to turn to their friends for help. Despite the fact that working with friends is often encouraged at university, this is only likely to be helpful if peers are able to assist their friends successfully. Furthermore, students were equally inclined to ask their parents as their instructor for help (although participants with high self-efficacy were more likely to seek out the instructor for help than were their counterparts with low self-efficacy). As a strategy for success, asking parents for help with biology may not be the most prudent choice. These results support the research of Karabenick and Knapp (1991), who also found that students were likely to seek help from informal sources, such as friends. The second source of help participants sought out was the Internet. Being able to distinguish reliable from unreliable sources on the Internet is dependent on information literacy skills and may be a challenge to many students.

Locus of control was not found to be significantly correlated with help seeking and clicker performance, nor was it predictive of grades. Research by Findley and Cooper (1983) suggests that college students may have a restricted range of locus of control scores compared to all individuals in their age group, which makes it less likely to be predictive of academic achievement. Similarly, in the present study, the range of scores for locus of control was also restricted, and this may be why this variable was not a significant predictor of the outcome variables.

Also, there was no overall significant relationship between help seeking and course grades. However, we did find that a significant negative relationship exists for participants with high, but not low, self-efficacy. It seems possible that students who felt that they could do well in the course, but had not done well in the first half of the course, were the ones who tended to seek help. The help-seeking data was collected 17 weeks into the course and participants would have already accumulated a substantial portion of their final grade. They may have sought help based on poor performance on earlier tests and the help (e.g., from friends) may not have resulted in substantial improvement in their performance.

Consistent with previous research (e.g., Caldwell, 2007; Kaleta & Joosten, 2007), participants reported that clickers increased their enthusiasm for class, facilitated their attention in class and their learning of their course material, and led to an increase in attendance. Overall, participants reported being positive about their clicker use in biology, and that positive perception was not dependent upon clicker or course performance (i.e., they did not feel positive because they were doing well on the clicker or test questions). We believe that this is an important finding, as science educators often struggle to find ways to motivate their students (Brewer, 2004; Dillon & James, 1977) and clickers may help serve this purpose.

In Study 1, we confirmed that there is a significant relationship between students' clicker record and course performance. We also confirmed that students with high self-efficacy tended to seek help if their clicker performance was in need of improvement and those that sought help tended not to have performed as well in the course overall. Finally, we found that students perceived the clickers positively, independent of their clicker or course performance. However, there were still a number of important questions that remained unanswered. One of the foci of the first study was the relationship between help seeking and clicker and course performance, but help seeking is only one of an array of learning strategies in which students may engage. If most students (except for those with high self-efficacy) do not tend to seek help as a result of their clicker performance, is it possible that their clicker performance is influencing their use of other learning strategies and, if so, how?

Also, in Study 1, there were three instructors, who may have used the clickers in different ways. This was recognized as a possible confounding factor. Therefore, it was important that in the second study, the data be collected earlier in the semester, with students being taught by only one instructor. This would help ensure that the form and manner of the clicker questions would be consistent prior to the survey.

Study 2

Introduction

Even though participants in Study 1 did not generally seek help based on their clicker performance (except for those participants with high self-efficacy), it does not mean that they were not processing the performance feedback and adjusting their learning strategies to improve their performance in the course. Barnett (2006) found that students indicated that receiving feedback on their comprehension was one of the most common benefits of using clickers. To examine if and how students are using this feedback to facilitate their learning, we examined whether students changed their learning strategies based on their clicker feedback and what form those changes took. In particular, we expanded the learning strategies under investigation to include rehearsal, elaboration, organization, self-regulation, effort regulation, and critical thinking, not just help seeking.

We also examined the moderating role of students' use of metacognitive self-regulation in the relationship between clicker performance and use of learning strategies. The literature supports the importance of metacognitive self-regulation to academic success (Svinicki, 2004). Students' ability to monitor their own cognitions enables them to successfully change strategies when it is apparent that their understanding has failed (Pintrich & de Groot, 1990). This may be a particular issue for first-year students, whose metacognitive skills are generally not as sophisticated as those of more senior students (Pintrich & Zusho, 2007).

Another difference from Study 1 is the timing of the research. Study 2 was conducted 6 weeks, rather than 17 weeks, into the course. During this period there was only one instructor and he asked questions in a consistent manner. The instructor primarily used the "peer instruction" method in asking clicker questions. Peer instruction is a variation on the "think-pair-share" active learning method (Rhem, 2009), in which students first think about the question and answer individually using the clickers. Next they partner with a classmate to discuss the question and respond to the same clicker question with their newly derived consensus answer. This method was chosen because researchers have found that students who engage in interactive discussion in the classroom, when each individual is accountable initially for their own response, leads to greater attention being paid in class and students making more sense of difficult concepts (e.g., Nicol & Boyle, 2003). In fact, Knight and Wood (2005) found that there were significant gains in learning and conceptual understanding when biology students have the opportunity to engage in peer instruction in class. Preszler, Dawe, Shuster, and Shuster (2007) suggested this may be particularly important in science programs, as students have been found to graduate without having a truly meaningful understanding of their discipline. They postulated that it is only when the use of clickers is paired with student-centred forms of learning, such as peer instruction, that clickers are likely to enhance learning. Furthermore, they suggested this may be why not all studies show gains in actual learning as a result of the use of clickers in class. The lack of consistency of instruction may be one reason that clickers had little impact on help seeking for the majority of participants in Study 1. Also, the differential use of the clicker questions may have had an impact on the clicker performance–course performance relationship as well as the relationship between students' perceptions of the clickers and their clicker and course performance.

Another difference between clicker use in studies 1 and 2 is that all students were informed of their cumulative clicker performance by means of two e-mails sent prior to the first term test. The e-mails also provided information on how to interpret their cumulative clicker performance and a list of on-campus learning resources they could turn to if they needed help. We examined whether receiving this e-mail specifically led students to change their learning strategies.

Method

Participants. Two hundred and sixty-one students (174 women) enrolled in a full-year introductory biology course at a large medical doctoral university in Canada participated in the study, a 19% response rate. The majority of participants were in the first year of their academic programs (98%) and in the Faculty of Science (70%), with a sizable minority in the Faculty of Health Sciences (18%).

Measures. Participants completed a 20-item survey. Eighteen of the items were developed for this study; the other two were multifaceted and taken from standardized measures. All of the items are addressed below.

Demographic items. Four items assessed participants' sex, program year, faculty, and use of clickers in other courses.

Clickers' effect on learning strategy use. Participants indicated how much using clickers in their biology course changed their use of learning strategies by completing an adapted version of the Learning Strategies scales of the MSLQ [Pintrich et al., 1993; responding on a scale of 1 (*greatly decreased*) to 5 (*greatly increased*); see Table 3 for information on the Learning Strategies scales].

Table 3
Number of Items, Cronbach's Alphas, and Sample Items on the Revised MSLQ Learning-Strategies Scales

MSLQ scale	Items	Alpha	Sample item
Rehearsal	4 (4)	.73 (.69)	"Say the material to yourself over and over when studying for this course"
Elaboration	5 (6)	.79 (.75)	"Relate the reading material to what you already know"
Organization	4 (4)	.75 (.64)	"Outline the material to help organize your thoughts when studying for the course"
Critical thinking	4 (5)	.72 (.80)	"Think about possible alternatives whenever you read or hear an assertion or conclusion in this course"
Self-regulation	5 (12)	.76 (.79)	"Make up questions to help focus your reading for the course"
Time management	3 (8)	.56 (.76)	"Make good use of your study time for this course"
Effort regulation	2 (4)	.63 (.69)	"Manage to keep working until you finish even when course materials are dull or uninteresting"
Peer learning	3 (3)	.61 (.76)	"Work with other students from this course to complete course assignments"
Help seeking	3 (4)	.62 (.52)	"Ask the instructor to clarify concepts you do not understand well"

Note: The number of items and alphas for the original scales of the MSLQ are provided in parentheses.

Clicker performance. Participants also completed three other items to indicate the effect they perceived that their clicker performance had on their study habits. Two items asked if their clicker performance influenced how they prepared for their biology lectures and tests and, if so, how. The third item asked if the e-mails that they received in weeks 3 and 5 of the course motivated them to change their study habits or seek academic help and, if so, what changes they made and why.

Metacognitive self-regulation. Metacognitive self-regulation was assessed using five items from the 12-item Metacognitive Self-Regulation scale of the MSLQ (Pintrich et al., 1993). Participants responded on a 5-point scale from 0 (*not at all true*) to 4 (*very true*). Cronbach's alpha for the five-item version was .71.

Help-seeking behaviour. Participants indicated, on a 5-point scale from 0 (n*ever*) to 4 (*all the time*), how often they had accessed 10 potential sources of help with their biology course. Specifically, they were asked to rate how often they turned to a biology TA, the course instructor, their parents, their friends, the biology course Web page, other Internet resources, biology study groups, the library, on-campus learning skills services, and other resources. The participants' ratings on help-seeking resources were subject to a principal components analysis to determine their factor structure. One factor, referred to here as the Helping Sources factor (Cronbach's alpha = .77), was extracted. This factor, comprised nine of the 10 sources of help (the "Other" category was dropped).

Perceptions of clickers. Participants rated the extent to which they perceived that the clickers affected their learning of the course material and their feelings about the clickers. All of the ratings were on a 5-point scale, with higher ratings indicating greater perceived learning, more positive feelings, etc.

Other clicker questions. Participants were also asked how often they try to answer the clicker questions correctly (0 = *never* to 4 = *always*).

Academic achievement. Participants were asked to give the researchers permission to access their admission average (i.e., their high school average used as the basis for their admission to the university), their test[2] and final course grades in introductory biology, and clicker responses. Permission was received from 81% for access to their admission average, 69% for course grades, and 73% for clicker responses. As in Study 1, clicker performance was calculated by dividing an individual participant's number of correct responses by the total number of questions answered. The overall mean clicker performance before the first term test was .54 ($SD = .14$).

Procedure. Students involved in the study were enrolled in two sections of a year-long biology course. Six weeks into the course, they received an e-mail invitation to participate in an online survey. A reminder was sent one week later. Interested participants clicked on a hyperlink in the e-mail to access the survey. To be entered into a draw for one of three Apple iPod Nanos (or gift certificates of equivalent value), participants were required to input their student numbers at the end of the survey. Upon completing the survey, participants clicked on a button to submit their responses. Submission of the survey was taken to indicate consent to participate. In each class the instructor included two to six clicker questions and peer instruction was the primary method of clicker-based instruction used.

Results

Similar to the first study, clicker performance before the first term test was a significant predictor of test performance. Specifically, the proportion of the participants' correct clicker responses was positively and significantly correlated with their term test score ($r = .51$, $p < .001$). A hierarchal multiple regression analysis was performed to examine the clicker performance–grades relationship, partialling out participants' admission average, sex, and clicker participation (i.e., number of clicker questions answered). Participants' clicker performance preceding the first-term test continued to be a significant predictor of test performance (see Table 4).

[2] Participants in Study 2 scored approximately 5% higher on first term test than the classes overall. This difference will be addressed later in the General Discussion of the paper.

Table 4
Correlations Between Predictors and Term Test Grade

Predictors	Zero-order correlation	Partial correlation	*t* test
Admission average	.53*	.39	5.08*
Sex	-.10	-.06	-.66
Clicker participation	.29*	.12	1.46
Clicker performance	.51*	.33	4.21*

Note. The partial correlations presented are those after all of the predictors have been entered into the equation in the order presented in the table (i.e., clicker performance last).
* $p < .001$.

We examined whether participants reported changing their learning strategies as a result of using clickers and found that 85% reported an increase in their use of at least one of the eight learning strategies. As can be seen in Figure 1, over 50% of students indicated that they increased their use of rehearsal, elaboration, metacognitive self-regulation, and effort regulation based on clicker use in the course. Over 40% reported increased use of critical thinking and organization, whereas a minority reported an increase in their use of peer learning and help seeking based on clicker use in the course. A repeated-measures ANOVA was performed to examine differences between participants' reported increase in the use of the eight learning strategies [$F(7, 227) = 19.7$, $p = .001$]. Post hoc analyses[3] revealed that participants reported increasing their use of metacognitive self-regulation significantly more, and their use of peer learning significantly less, than they reported increasing their use of other strategies. They also reported increasing their use of help seeking significantly less than they reported increasing rehearsal, elaboration, and effort (all *p*s < .05).

[3] A Bonferroni correction was employed to adjust for multiple comparisons.

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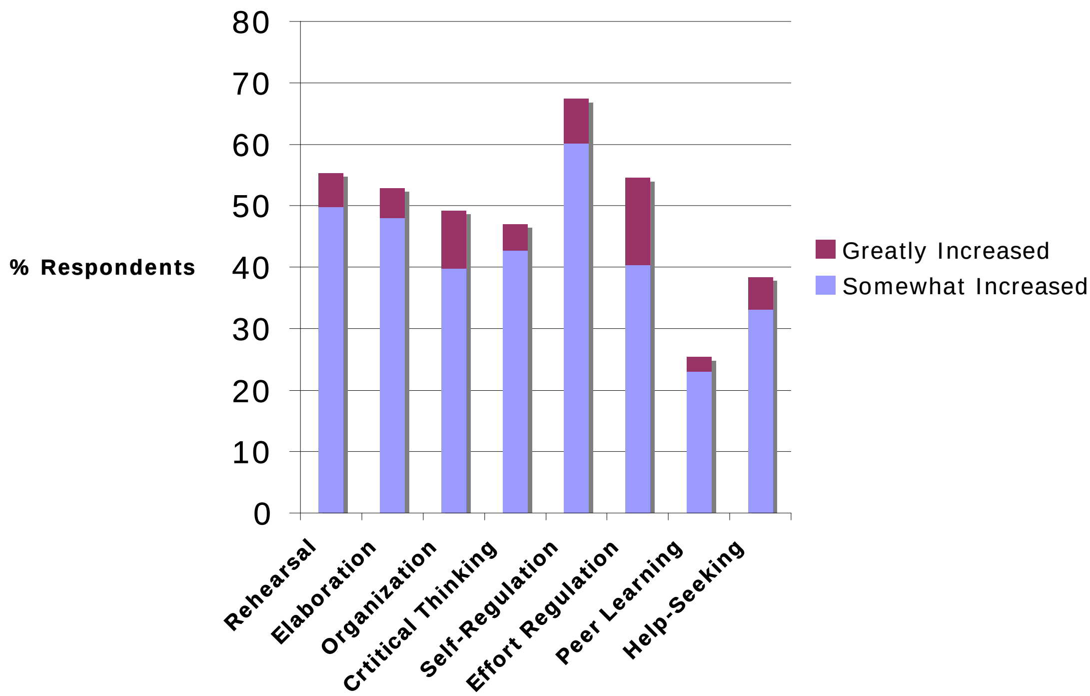

Figure 1. Learning strategy use increase as a result of clickers.

Participants also indicated if their performance on the clicker questions influenced how they prepared for the biology lectures and exams. Only 23% of participants indicated that their performance on clicker questions influenced how they prepared for biology lectures, whereas 62% indicated that their performance influenced how they prepared for the first term test.

We also examined whether receiving directed feedback by means of the e-mail on their clicker record might lead students to change their learning strategies. Although only 20% of students reported changing their learning strategies based on the e-mail, the group that changed their strategies had significantly poorer clicker performances (M = .42, SD = .202) than the group that did not make a change [M =.51; SD = .225; t(183) = -2.10, p = *.05*].

None of the other indicators of change in learning strategies was significantly related to clicker performance. Participants' clicker performance was not significantly correlated with their changes in learning-strategy use as assessed by the eight revised MSLQ scales (Pintrich et al., 1993; see Table 5). Participants who reported changing either their lecture or test preparation did not differ significantly on their clicker performance from those who did not report making these changes [t(184) = -1.02, *ns*, for lectures and t(184) = .90, *ns*, for term tests].

Finally, we investigated participants' use of metacognitive self-regulation. Participants who reported changing their lecture preparation had significantly higher self-regulated learning scores than those who indicated no change [t(246) = 3.12, $p < .005$; M = 2.64 (SD = .75) and M = 2.30 (SD = .74), respectively]. Furthermore, participants' metacognitive self-regulation was significantly related to their increase in the use of five of the eight learning strategies assessed by the revised MSLQ (see Table 5). However, participants who reported changing their preparation for the term test did not differ significantly on their metacognitive self-regulated learning scores from those who indicated making no change [$t(245) = 1.43$, *ns*].

Neither the participants who reported changing their lecture preparation, nor those who reported changing their preparation for the term test, differed significantly on their term test grade [$t(170) = 1.32$, *ns*, and $t(170) = -.24$, *ns*, respectively] from their nonchanging counterparts. Finally, participants' changes in learning strategy with the revised MSLQ were not significantly related to their performance on the first term test, with one exception: rehearsal (see Table 5).

Table 5
Correlations Between Revised MSLQ Learning Strategies and Clicker Performance, Self-Regulated Learning, and Term Test Grade

Revised MSLQ learning strategies	Clicker performance	Self-regulated learning	Term test grade
Rehearsal	-.16	.15	-.25*
Elaboration	-.04	.34*	-.03
Organization	-.10	.29*	-.13
Critical thinking	.01	.30*	-.05
Self-regulation	-.09	.25*	-.07
Effort regulation	-.07	.24*	-.06
Peer learning	.02	.20	.02
Help seeking	-.11	.18	-.11

*$p < .001$.

Consistent with Study 1, participants' help seeking as assessed by the Helping Sources factor was not significantly related to clicker performance ($r = -.2$, *ns*) or term test performance ($r = -.17$, *ns*). Also, participants sought help with their biology course from friends more than any other resource, such as the biology course Web page [$t(256) = 2.04$, $p < .05$] or the biology TA [$t(255) = 12.03$, $p < .001$] (see Table 6). Contrary to Study 1, participants were significantly more likely to seek out their instructor than their parents for help with the course [$t(256) = 6.85$, $p < .001$] (see Table 6), but seeking out the instructor was still rated as rare (1.19 on a scale of 0 to 4).

Table 6
Sources Students Accessed for Help

	M	*SD*
Friends	2.64	1.18
Biology Web page	2.44	1.16
Other Internet	1.71	1.31
TA	1.47	1.21
Biology study group	1.30	1.42
Library	1.19	1.28
Instructor	1.02	1.12
Learning skills	.53	.98
Parent	.48	.96

The vast majority of students (95%) reported that they "always" or "almost always" tried to answer the questions correctly, despite the fact that only 54% of the clicker questions were answered correctly over the 6-week period.

Two items were repeated from Study 1 to determine participants' perceptions of the clickers. As in Study 1, 87% of participants felt that the clickers somewhat or greatly facilitated their learning of the course material and 84% felt positive about using clickers in their course. These two items were not significantly related to either participants' clicker or term test performance (r ranged from .01 to .19, *ns*).

Discussion

As in Study 1, clicker performance was a significant predictor of achievement, in this case of term test grades, even when controlling for prior academic performance, clicker participation, and sex effects. This finding, in conjunction with participants' reports that they attempt to answer clicker questions correctly, demonstrates that students do take responding to clicker questions seriously and do not simply respond arbitrarily to earn the participation grade.

Most students reported changing their learning strategies based on their use of clickers and their reported increases in strategy use was related to their metacognitive self-regulation for five of the eight strategies assessed. Interestingly, those reported changes were not related to their actual clicker performance or their performance on the term test (except for changes in rehearsal use). This may suggest that even though participants reported increases in the use of several different learning strategies, they were not necessarily skilled in selecting or properly employing the strategies that would lead to increased test scores. In fact, we found that the increased use of rehearsal was negatively correlated with term test performance. That is not surprising, as Svinicki (2004) and others (e.g., Biggs & Tang, 2007) have noted that learners who use repetition as a strategy also tend to take a more shallow approach to learning, which leads to poorer recall. This means that, even though we might want to have learners change or increase their strategy use as a result of their clicker feedback, we also want them to be more focused on which strategies they select, as not all strategies are well suited to deep learning. As Biggs and Tang (2007) indicate, convincing students not to use rehearsal as the dominant learning strategy can be difficult, as it is easier than others, such as elaboration or organization). The apparent inability of many students to translate clicker feedback into improved academic performance is reflected in the research of Addison, Wright, and Milner (2009), who found that only high-achieving students showed academic improvement after the introduction of clickers.

Those participants who reported increasing their use of one or more learning strategies tended to increase metacognitive self-regulation, effort regulation, rehearsal, elaboration, organization, and/or critical thinking, but few had increased their use of peer learning or help seeking. Their lack of use of help seeking, even when e-mailed a list of learning resources , is consistent with Study 1 and suggests that simply informing students of what resources are available does not necessarily motivate them to avail themselves of those resources. Also congruent with Study 1 is that participants reported seeking help from their friends more often than formal sources of help, such as the course instructor, TA, or learning skills services. Despite the fact that friends were the number one–cited source for help, the biology course Web page was second, which is promising, as it is an excellent resource. It may be that students seek help from resources that are perceived to be less intimidating, less ego threatening, or more convenient.

It was noteworthy that the 20% of participants who reported changing their learning strategies as a result of receiving the e-mail had significantly poorer clicker records than those who did not. This suggests that there may be some benefit to adopting the e-mail intervention, at least for the poorer performing students. Providing more explicit information about the diagnostic value of clicker performance and how to use effective learning strategies to improve learning of the material may be necessary to make the clicker feedback and e-mail intervention lead to improved learning.

Finally, also consistent with Study 1 and the literature, most students reported enjoying the use of clickers in the classroom (Caldwell, 2007; Judson & Sawada, 2002), regardless of clicker or term test performance.

General Discussion

The results of the two studies confirm that clicker performance is highly correlated with course grades and that the relationship is maintained even after partialling out past academic performance, clicker participation, self-efficacy (Study 1 only), and sex. Establishing the clicker–course grades relationship is important, as it is apparent that by providing meaningful formative feedback to students, we may have a mechanism to improve student success if we can find an approach that will get them to seek help or alter other learning strategies when necessary.

Although students reported making changes in study strategies based on their clicker performance, these reported changes did not generally relate to their actual clicker performance or their performance on the term test. This is a significant finding, as one of the assumptions underlying clicker use in the classroom is that students will act on feedback received in class to make changes in their learning strategies which, in turn, will improve performance (Bruff, 2009). The formative feedback received both in class and via e-mail was not sufficient to cause most students to seek help or successfully alter their learning strategies. Even though the e-mail intervention did appear to influence some students who performed poorly in class to change their learning strategies, overall, no difference was found between those who changed their learning strategies and those who did not. It seems possible that e-mail may be effective in getting some students to pay attention to their performance but is not sufficient to ensure a successful change in their approaches to learning.

Svinicki (2004) has suggested that postsecondary students tend to utilize only one or two learning strategies, regardless of the task at hand. Furthermore, she states that their response to a new learning task is to try harder, rather than modifying their strategies. It may be that students' reported increases in learning strategy use in Study 2 reflect their efforts to try harder, rather than using a new strategy or more effectively using an existing strategy. Future studies might wish to investigate more explicitly whether students take a surface (minimal efforts to meet course requirements) or deep (more achievement or strategic orientation) approach to learning, perhaps by utilizing the Lancaster Inventory of Approaches to Learning (Entwistle, Hanley, & Hounsell, 1979). Biggs and Tang (2007) suggest that it is possible to shift students' approach to learning, but that both teaching and assessment approaches may lead them to feel a surface approach is sufficient to meet their goals. Biggs and Tang (2007) suggest instructors may need to change their teaching methods to focus on activities that lead to deep learning, such as emphasizing depth rather than breadth in course coverage. Investigating how faculty encourage deep learning through their teaching practices is another avenue of research that could be investigated.

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Although students reported changing their learning strategy use as a result of the clickers, it would be necessary to monitor their behaviour, or at least have students record in which specific activities they are engaged, to determine if they were truly changing their strategies based on the clicker feedback and if they were effective in using the changed strategies. One of the new social networking tools, such as Twitter, might be an easy way for students to record their own behaviour on a daily basis and for researchers to explore the clicker performance–learning strategy use relationship more thoroughly.

In Study 2, participants' self-regulation was related to their increases in self-reported learning strategy use for five of the eight strategies (i.e., the higher participants scored on self-regulation, the more likely they were to increase their use of learning strategies based on their clicker use), but, as outlined above, strategy use was not related to performance on the term test. Students are not necessarily skilled at metacognition and therefore may not be able to monitor their own comprehension effectively (Zimmerman & Paulsen, 1995). It has been suggested that when students have inaccurate perceptions of their self-efficacy or when they are too optimistic about their level of preparedness for tests, they may adopt a rather casual attitude to studying (Zimmerman & Paulsen, 1995). Given the high entrance average of many students in our studies (mean admission average was 88% for Study 1 and 89% for Study 2), it is perhaps not surprising that students may not have been as careful about their formal self-monitoring as they need to be. Research suggests that students can be taught to be self-regulated learners (e..g, Pintrich, 1995), and Coppola (1995) recommends numerous practices in this regard. They include using counterintuitive examples, so that students are forced to confront their own misconceptions, providing heuristics for learning and using think-aloud strategies or cognitive modelling. Also, Bruff (2009) has suggested that instructors give differential points based on how confident students are in their clicker responses. This method forces students to assess their understanding of their answers and may help develop their metacognive self-awareness. All of these practices are well suited to the clicker classroom and may help students to improve their performance.

It was also somewhat surprising that students seldom reported asking their instructors or TAs for help, but more often relied on peers for learning support. Despite the fact that peers may be a good choice for solving some learning difficulties, it would also seem important for students to realize the critical role faculty and graduate teaching assistants may play in supporting their academic success (Pascarella & Terenzini, 2005). It appears that, at least in our first-year biology classes, students are unlikely to approach those who might most positively influence their learning. Even though students often believe that they will get the best help from the instructor, they still turn to peers; reasons given include not wanting to appear unintelligent in front of a teacher and feeling that friends have an obligation to help. Also, turning to peers or visiting the biology Web page (Study 2) may simply be more convenient (Ryan & Pintrich, 1998).

The ability of clickers to impact on test performance will depend upon students using their clicker performance to change their study strategies successfully. However, this will only lead to an increase in test grades if there is a strong congruence between clicker questions asked in class and questions asked on exams (Carnaghan & Webb, 2005). It is interesting to note that students in Barnett's (2006) study claimed to have a preference for being asked conceptual and diagnostic questions, rather than factual questions. Particularly if an instructor is interested in using active teaching strategies such as peer instruction with the clickers, it appears to be important that students are asked questions at a deeper level than simple factual questions. Only deep-level questions are likely to lead to good discussion in class (Biggs & Tang, 2007; Svinicki, 2004). Caldwell (2007) provides suggestions about how to design good clicker questions. Of particular interest to science instructors would be her recommendation to create questions that focus on misconceptions and answers that focus on common errors. Given students' well-known tendency to hold on to misconceptions in science (Smith, diSessa, & Roschelle, 1993), even after class instruction, this may provide a technique for students to begin to address this problem in comprehension.

Furthermore, the results of this research support the finding that students rate clickers positively (Caldwell, 2007; Judson & Sawada, 2002) and do so independently of their performance on clicker and test questions. Although this might seem a trivial finding, it is important, particularly for science students, as many report not liking science (Duncan, 2005). Therefore finding strategies, such as using clickers, to engage students in their learning seems paramount in encouraging science students to go forward in the discipline (Kaleta & Joosten, 2007).

One possible limitation to these studies is that students in both studies scored approximately 4% to 5% higher on the tests than the classes as a whole. It may be that a third variable, such as motivation, predicts higher engagement, which leads to both higher grades and increased likelihood of participation in research. Even though the difference is not dramatic, the relatively higher academic performance of the participants may be a factor in generalizing these results.

In summary, our two studies add substantially to the literature on the use of clickers in the classroom by demonstrating that clicker performance does predict students' test and course performance. Unfortunately, students do not generally alter their help seeking or other learning strategies based on their actual clicker performance (even though they report making changes based on the clickers). Further, when participants report making changes to their learning strategy use, the changes were not generally related to their performance in the course. It may be that students need to be taught more explicitly about metacognitive self-regulation and effective learning strategy use if they are to be successful in improving their academic performance. As Pintrich and Zusho (2007) have suggested, first-year students may not be aware of the different learning strategies that they may use. They may also need to adapt their learning strategies from the high school environment to the more complex university milieu. This lack of knowledge of effective learning strategies may be one reason they do not seek help from learning services, as they may be unaware of the impact of different learning strategies on their achievement. Clickers play an important role in informing students about their own learning in the classroom but, to be truly effective, instructors may need to teach students how and why self-regulation and effective use of learning strategies are essential for academic success at university.

References

Addison, S., Wright, A., & Milner, R. (2009). Using clickers to improve student engagement and performance in an introductory biochemistry class. *Biochemistry and Molecular biology Education*, *37*(2), 84–91. http://dx.doi.org/10.1002/bmb.20264

Barnett, J. (2006). Implementation of personal response units in very large lecture classes: Student perceptions. *Australasian Journal of Educational Technology*, *22*, 474–494. Retrieved from http://www.ascilite.org.au/ajet/ajet22/

Beatty, I. (2004). Transforming student learning with classroom communication systems. *Educause Research Bulletin*, *2004*(3), 2–13. Retrieved from http://net.educause.edu/ir/library/pdf/ERB0403.pdf

DOI: http://dx.doi.org/10.5206/cjsotl-rcacea.2010.1.6

Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university* (3rd ed.). Berkshire, England: Open University Press.

Brewer, C. A. (2004). Near real-time assessment of student learning and understanding in biology courses. *BioScience, 54,* 1034–1039. http://dx.doi.org/10.1641/0006-3568(2004)054[1034:NRAOSL]2.0.CO;2

Bruff, D. (2009) *Teaching with classroom response systems: Creating active learning environments.* San Francisco: Jossey-Bass.

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *Life Sciences Education*, *6*(1), 9. Retrieved from http://lifescied.org/cgi/reprint/6/1/9.pdf http://dx.doi.org/10.1187/cbe.06-12-0205

Carnaghan, C., & Webb, A. (2005). *Investigating the effects of group response systems on learning outcomes and satisfaction in accounting education*. Retrieved from http://accounting.uwaterloo.ca/research/publications/carnaghan_webb_aaa_working_paper.pdf

Coppola, B. P.(1995). Progress in practice: Using concepts from motivational and self-regulated learning research to improve chemistry instruction. *New Directions for Teaching and Learning, 63,* 87–96. http://dx.doi.org/10.1002/tl.37219956310

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297–334. http://dx.doi.org/10.1007/BF02310555

Davis, S. (2003). Observations in classrooms using a network of handheld devices. *Journal of Computer Assisted Learning*, *19*, 298–307. http://dx.doi.org/10.1046/j.0266-4909.2003.00031.x

Dillon, J. C., & James, R. K. (1977). Attitudes of black college students towards science. *School Science and Mathematics*, *77*(7), 592–600. http://dx.doi.org/10.1111/j.1949-8594.1977.tb09393.x

Duncan, D. (2005). *Clickers in the classroom: How to enhance science teaching using classroom response systems.* San Francisco: Addison Wesley.

Entwistle, N., Hanley, M., & Hounsell, D.(1979). Identifying distinctive approaches to studying. *Higher Education, 8,* 365–380. http://dx.doi.org/10.1007/BF01680525

Findley, M. J., & Cooper, H. M. (1983). Locus of control and academic achievement: A literature review. *Journal of Personality and Social Psychology, 44,* 419–427. http://dx.doi.org/10.1037/0022-3514.44.2.419

Judson, E., & Sawada, D. (2002). Learning from past and present: Electronic response systems in college lecture halls. *Journal of Computers in Mathematics and Science Teaching, 21*(2), 167–181.

Kaleta, R., & Joosten, T. (2007). Student response systems: A University of Wisconsin study of clickers. *Educause Research Bulletin, 10,* 2–12. http://www.blog.utoronto.ca/in_the_loop/2007/05/clickers_in_the.html

Karabenick, S. A., & Knapp, J. R. (1991). Relationship of academic help seeking to the use of learning strategies and other instrumental achievement behavior in college students. *Journal of Educational Psychology, 83,* 221–230. http://dx.doi.org/10.1037/0022-0663.83.2.221

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell biology Education, 4,* 298–310. Retrieved from http://www.lifescied.org/cgi/content/abstract/4/4/298 http://dx.doi.org/10.1187/05-06-0082

Morin, D., Thomas, J. D. E., Barrington, J., Dyer, L., & Boutchkova, M. (2009). The "clicker" project: A scholarly approach to technology integration. In P. Daly & D. Gijbels (Eds.), *Real learning opportunities at business school and beyond: Vol. 2. Advances in business education training* (pp. 97–107).New York: Springer.

Nicol, D. J., & Boyle, J. T. (2003). Peer instruction versus class-wide discussion in large classes: A comparison of two interaction methods in the wired classroom. *Studies in Higher Education, 28,* 457–473. Retrieved from http://www.ph.utexas.edu/~ctalk/bulletin/glasgow1.pdf http://dx.doi.org/10.1080/0307507032000122297

Pascarella, E. T., & Terenzini P. T. (2005). *How college affects students: Vol. 2. A third decade of research.* San Francisco: Jossey-Bass.

Pintrich, P. R. (1995). Understanding self-regulated learning. *New Directions for Teaching and Learning, 63,* 3–12. http://dx.doi.org/10.1002/tl.37219956304

Pintrich, P. R., & de Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82,* 33–40. Retrieved from http://www.stanford.edu/dept/SUSE/projects/ireport/articles/self-regulation/self-regulated%20learning-motivation.pdf http://dx.doi.org/10.1037/0022-0663.82.1.33

Pintrich, P. R., Smith, D. A., Garcia, T., McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53,* 801–813. http://dx.doi.org/10.1177/0013164493053003024

Pintrich, P. R., & Zusho, A. (2007). Student motivation and self-regulated learning in the college classroom. In R. P. Perry & J. C. Smart (Eds.), *The scholarship of teaching and learning in higher education: An evidence-based perspective* (pp. 731–810). The Netherlands: Springer. http://dx.doi.org/10.1007/1-4020-5742-3_16

Preszler, R. W., Dawe, A., Shuster, C. B., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *CBE—Life Sciences Education, 6*(1), 29–41. http://dx.doi.org/10.1187/cbe.06-09-0190

Rhem, J. (2009). Clickers. *National Teaching and Learning Forum, 18*(3), 1–3.

Ryan, A. M., & Pintrich, P. R. (1998). Achievement and social motivational influences on help seeking in the classroom. In S. A. Karabenick (Ed.), *Strategic help seeking: Implications for learning and teaching* (pp. 117–140). Mahwah, NJ: Lawrence Erlbaum.

Smith, J. P., diSessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *Journal of the Learning Sciences, 3,* 115–163. http://dx.doi.org/10.1207/s15327809jls0302_1

Svinicki, M. D. (2004) *Learning and motivation in the postsecondary classroom.* Bolton, MA: Anker.

Trice, A. D. (1985). An academic locus of control scale for college students. *Perceptual and Motor Skills, 61*, 1043–1046. http://dx.doi.org/10.2466/pms.1985.61.3f.1043

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for self-regulation. *New Directions for Teaching and Learning, 63,* 13–28. http://dx.doi.org/10.1002/tl.37219956305