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The impact of individual and shared clicker use on students' collaborative learning

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ABSTRACT

Clickers have become common-place in university classes and are often used to foster collaborative learning. However, few studies have investigated learners' actual interactions during clicker activities to determine how often collaborative reasoning occurs. Therefore, the current study analyzed the interaction that occurred between students when using clickers. Undergraduate students ($N = 44$) enrolled in an English grammar course used clickers to complete practice activities during four 2-h classes. Students shared clickers in pairs and small groups for two classes, but had their own clickers for the other two classes. In all four classes, their interaction was audio-recorded. Analysis of their transcribed discussions ($N = 498$) revealed that students were more likely to engage in collaborative reasoning and select the correct answer during shared clicker activities. Exit questionnaires revealed that students preferred sharing clickers to having their own. Implications for teaching and suggestions for future research are discussed.

1. Introduction

Known by a variety of labels, such as student response systems, personal response systems, audience response systems, and classroom feedback systems, "clickers" are an interactive technology in which students use a hand-held transmitter to provide electronic responses to multiple-choice or true-false questions embedded in slide-show presentation software such as PowerPoint. Once students have submitted their answers, automatically-generated graphs anonymously illustrate the distribution of their answers. Clickers have been widely used in university settings with undergraduate students in large enrollment, introductory science, engineering, and medicine classes (Caldwell, 2007) as a way to improve student engagement during lectures. Clickers have been incorporated into humanities and social sciences classes as well, such as foreign languages (Cardoso, 2011; Serafini, 2013), graphic design (Gachago, Morris, & Simon, 2010), teacher education (Cheesman, Winograd, & Wehrman, 2010), and marketing (Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 2013), and have been used for upper-division classes (Milner-Bolotin, Antimirova, & Petrov, 2010), as well as graduate-level seminars and science labs (Sevian & Robinson, 2011).

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As highlighted in a systematic review of clicker studies (Kay & LeSage, 2009), clicker use has been associated with several positive outcomes, including increased attendance, greater student interaction, and enhanced learning. Both instructors and students have responded positively to the feedback function of clickers, particularly for students who appreciate the anonymity of their answers (e.g., Blasco-Arcas et al., 2013; Gachago et al., 2010). For classes with large enrollments, clickers have been used to stimulate frequent and positive interaction (Caldwell, 2007; Trees & Jackson, 2007), generate effective peer discussions (Bergtrom, 2006), and promote active learning (Elliott, 2003). Because they engage students in lectures, including students who may not typically contribute during the traditional lecture format, clickers have been used as a tool to foster collaborative learning (Beekes, 2006; Crouch & Mazur, 2001; Smith et al., 2009).

1.1. Collaborative learning

Collaborative learning is based on the premise that students become actively involved in the learning process, with their subsequent interaction facilitating knowledge consolidation and acquisition, and promoting higher order thinking skills (Wolfe, 2012). While often used synonymously with cooperative learning, collaborative learning refers to the philosophy of interaction as opposed to formal efforts to structure interaction in ways that facilitate the accomplishment of a goal (Panitz, 1999). Cooperative learning is typically associated with K-12 pedagogical approaches that call for a prescribed division of labor amongst students and are used in subjects with well-structured knowledge domains (Slavin & Cooper, 1999). In contrast, collaborative learning tends to be found in higher education contexts when students are asked to work with their peers (Brufee, 1999). In other words, collaborative learning arises naturally when students mutually engage in efforts to solve a problem together (Johnson, Johnson, & Smith, 1998; Resta & Laferriere, 2007). And unlike peer teaching, where one student tutors another, collaborative learning involves the co-construction of knowledge (Foot, Morgan, & Shoot, 1990, as cited in Gachago et al., 2010).

Collaborative learning is believed to increase student engagement in the learning process, facilitate active processing of course content, enhance critical thinking and higher-order learning, and promote metacognitive awareness and problem-solving abilities (Crouch & Mazur, 2001; Gokhale, 1995; Michaelson, Knight, & Fink, 2004). Furthermore, students may benefit from peer explanations because they can describe the concepts using similar language (Caldwell, 2007; Nicol & Boyle, 2003). However, students may not necessarily appreciate collaboration, particularly if they have had negative previous experiences with group work (Caulfield & Hodges Persell, 2006). If they have negative perceptions about collaboration, then it can influence their attitudes toward the course content (Slusser & Erickson, 2006). In addition, it is possible that one student in a pair or group can dominate the conversation (Nielsen, Hansen, & Stav, 2014; Wolfe, 2012), which can negatively impact students' willingness to engage in collaborative learning. Furthermore, the need to compromise in order to reach consensus may be frustrating for some students (Gachago et al., 2010).

1.2. Collaboration and clickers

Although widely regarded as promoting collaborative learning, it is possible that clicker activities, especially those in which students answer individually, do not generate the conditions believed to foster collaborative learning. As researchers have pointed out (Cheong, Bruno, & Cheong, 2012), social construction of knowledge is not automatically imbued in the clicker system's process, and if they are used only for question-answer-feedback sequences, clicker activities may resemble behavioristic learning. Simply putting clickers in the hands of students does not automatically create an engaged classroom of students actively participating in collaborative learning (Trees & Jackson, 2007). Because collaboration requires that students actively participate, it may require an adjustment from their traditional role in lecture classes, with some students uninterested in adopting a new learning method (Kay & LeSage, 2009). Within groups, there may be uneven levels of participation among students, such as if one student presents arguments for an answer while other students simply listen (Lucas, 2009). Even when students are asked to share clickers and reach consensus before selecting an answer, they may not necessarily engage in collaborative decision-making. In fact, when required to share clickers in a recent study, 80% of university graphic design students indicated that they would have preferred to have their own clicker (Gachago et al., 2010).

In light of the purported role for clickers in encouraging peer discussions, active learning, and student interaction, an important question is whether clicker use does in fact facilitate collaborative learning. Comparative studies have found that peer instruction clicker activities (Crouch & Mazur, 2001; Mazur, 1997), in which students individually select an answer, discuss with peers, and then select an answer again, are more effective than traditional lectures (Duncan, 2005; Mazur, 1997), class-wide discussions (Nicol & Boyle, 2003), and clicker activities in which students answer individually only (Jones, Antonenko, & Greenwood, 2012). Such findings suggest that collaborative learning occurred when students discussed their answers, but it was beyond the scope of these studies to analyze the students' interactions. Although Nielsen and colleagues video-taped students while they were discussing clicker activities, their analysis focused on the amount of time individual students spent presenting arguments, as opposed to the degree of collaboration evident in each argument (Nielsen et al., 2014). As a result, it is difficult to determine under which conditions students engage in the critical thinking and higher-order skills attributed to collaborative learning versus when their discussions are more akin to peer teaching with one expert student simply explaining the answers.

1.3. Purpose of the study

The purpose of the current study was to investigate the nature of students' collaborative learning during clicker activities. It explores whether their collaborative learning is impacted by different ways of using clickers, specifically whether students have individual clickers or share a clicker with peers. Although some studies have analyzed the amount of time students spent giving arguments and making comments while using clickers (e.g., Nielsen et al., 2014), most have relied on self-report data. Therefore, this study analyzed collaborative learning by examining students' reasoning during clicker use rather than their impressions of their interactions. The first research question was: "Does shared clicker use facilitate collaborative learning?" Collaborative learning was operationalized as the occurrence of joint reasoning and accurate question answering. Based on the previous research that has shown a positive effect for individual clickers combined with peer discussion (Crouch & Mazur, 2001; Duncan, 2005; Jones et al., 2012; Mazur, 1997; Nicol & Boyle, 2003), it is possible both individual and shared clicker use will facilitate joint reasoning and accurate answers. However, because shared clicker use may place a greater demand on students to discuss items before answering, it is possible that sharing clickers may result in greater collaborative reasoning and more accurate answering. Therefore, we made no predictions about the directionality of possible differences. In light of previous research that has shown that negative feelings toward collaboration can erode its value (Caulfield & Hodges Persell, 2006; Slusser & Erickson, 2006), the second research question was: "What are students' perceptions about shared and individual clicker use?" Although we expected the students to have positive reactions to the use of clickers generally, we made no predictions as to whether they would express a preference for shared or individual clicker use.

2. Method

2.1. Participants and instructional setting

The participants were 44 undergraduate students (40 women, 4 men) at an English medium university in Montreal. The majority of the students (40/44) were enrolled in a bachelor's degree program in early childhood education, while the remainder were studying degrees in art education (2) and child studies (2). They ranged in age from 19 to 54 years, with a mean age of 24.6 years ($SD = 8.3$). In terms of their language background, most of the students were first language speakers (L1) of English (30/44), while the others reported a variety of L1 backgrounds including French (7), Armenian, Dutch, Farsi, Italian, Polish, Spanish and Tamil. All but one student reported having knowledge of at least one additional language. Although they knew a variety of languages and lived in the multilingual setting of Montreal, the students did not have prior formal training in linguistics or English grammar.

The participants were taking a required first-year class in English grammar, taught by the second researcher, which met for one, 2-h class per week over a 13-week semester. The class was reserved for education students, but did not focus on how to teach grammar. Instead, the class objectives were to help students acquire knowledge of English grammar so that they could analyze sentences and identify errors. It provided an overview of basic concepts in English grammar, such as parts of speech, phrases, clauses, verb tenses, and punctuation conventions. Although the class was largely lecture-based, each session included practice activities in which students were asked to apply concepts by analyzing new sentences. The students were assessed based on their performance on three in-class quizzes, a paper, and a final exam. Neither attendance nor clicker performance was included as part of the students' summative assessment.

2.2. Materials

The materials consisted of three questionnaires and the clicker practice activities. The first questionnaire was a background information form used at the beginning of the semester to elicit information about the students and their perceptions about the class (Appendix A). It included 10 Likert-scale items (1 = *Not true*; 5 = *Very true*) in which students indicated their agreement with statements about their attitudes toward the class (their interest, their confidence, the effort required, class usefulness) and types of learning activities (comparing answers, working with peers, listening to the teacher, individual practice, use of technology). The final question asked whether the students would take the course even if it were not required for the degree programs. The questionnaire was informally pilot-tested with students who had taken a similar grammar course to ensure that the items and the rating scale were clear. Based on the pilot tests, the wording of a few items were modified slightly.

The second questionnaire was administered after each of the four clicker practice activities (Appendix B). It contained five Likert-scale items that used the same descriptors as the background questionnaire. Three items involved statements about the contribution of the practice activities to their understanding of the grammar points, their enjoyment of the clicker activities, and the usefulness of clickers for providing feedback. One item elicited the students' preference for traditional activities (listening to the teacher explain and give examples) as opposed to practice activities. The items were created based on the impressions of students who had previously taken the grammar class or had experience using clickers in applied linguistics classes. There were two versions of the final item, depending on whether the students had completed shared or individual clicker items. For the two shared clicker questionnaires, the students were asked if they would have preferred to work individually. Conversely, for the two individual clicker questionnaires, they were asked if they would have preferred to work with a partner.

The last questionnaire was administered at the end of the semester to elicit the students' perceptions about the clicker activities (Appendix C). It contained eight Likert-scale items that used the same scale and descriptors as the previous questionnaires. Four items elicited the students' views about the usefulness and enjoyment of the clicker activities and their value for providing feedback and keeping answers anonymous. Three items targeted practice activities generally and whether the usefulness of clickers varied by topic. The final item explored whether students preferred to work individually rather than collaboratively. Pilot tests with students who had previously taken a similar class resulted in minor modifications to the wording of a few items.

Clicker practice activities were created for use in the classes held in weeks 4, 6, 10, and 12 of the semester. These classes were chosen for clicker activities because the topics were appropriate for multiple-choice practice activities, and there were no scheduled quizzes or exams. The clicker practice activities were used to review material from previous classes and to reinforce newly-introduced concepts. Three clicker activities consisted of 8–10 items (weeks 4, 5, 10), but Week 12 provided 19 clicker items to help students review and prepare for their final exam. Across the four classes, a variety of grammar points were targeted. In week 4, clicker activities were used with types of verbs, phrases, and sentences (e.g., subjects, verbs, and predicates). Week 6 focused on differentiating between phrases and clauses, and identifying sentence types (i.e., simple, compound, and complex sentences). Week 10 reviewed verb tenses and converting direct speech to reported speech. Finally, in week 12, the target structures were articles, count/noncount nouns, pronoun usage, and apostrophe conventions.

All clicker activities followed the same format, which was multiple choice questions shown on PowerPoint slides. The number of response options varied depending on the complexity of the question, but each item included a "not sure" option, which was often phrased humorously. For example, one item asked students to identify the functional components of the sentence *I bought a new car on Tuesday*. The answer choices included (a) Subject/Verb, (b) Subject/Verb/Object, (c) Subject/Verb/Object/Adverbial, and (d) As if you could afford a new car. In this example, option (d) functioned as the "not sure" option that students could select if they were unable to identify the correct answer, which was option (c).

2.3. Procedure

The instructor incorporated the four clicker activities into the normal instructional routine of the English grammar class, with the clicker items distributed throughout the lecture. The typical sequence was to provide a few clicker items at the beginning of class to review previous material, followed by cycles of new lecture content and clicker items to practice the new concepts. Each clicker item was shown on a PowerPoint slide, and after the students entered their answers, the instructor would advance to the next slide to show a figure with the percentage of students choosing each answer. If the majority of the students had answered correctly, a short explanation was given to reinforce the correct answer. However, if there were a lot of incorrect answers, the instructor provided additional information to clarify the correct answer and explain why the distractor items were incorrect. The procedure for administering clicker activities was the same whether the students had individual or shared clickers. Students were always encouraged to discuss their answers with their peers before and after clicking in. This was also true of days when practice activities were used without clickers.

On each clicker day, a research assistant attended the class to distribute clickers and place digital audio-recorders throughout the room to capture voices of students in the vicinity of each recorder. In order to minimize potential disruptions, the research assistant placed the clickers and recorders at the beginning of the class as students were arriving. Students were asked to state their name as they took a seat to identify their voice on the audio-recordings, which allowed the voices of non-consenting students ($N = 11$) to be excluded from the transcripts. For the classes in weeks 4 and 10, the research assistant distributed fewer clickers so that the students would have to share. In weeks 6 and 12, each student had a clicker. While video recordings may have allowed for easier analysis in terms of identifying speakers, audio recordings were chosen because they were less disruptive to the class activities and were less likely to make the participants feel uncomfortable.

2.4. Data coding & analysis

The questionnaire responses were converted into numeric values using the following scale: very true = 5, mostly true = 4, moderately true = 3, slightly true = 2, not true = 1. In order to ensure that high total values corresponded with positive values, all negatively worded statements were reverse scored. The audio-recordings were transcribed by a research assistant, after which each transcript was checked against the audio-recordings by a second research assistant. Appendix D provides the question, target sentence, and answer options for all of the examples included in this manuscript.

The student talk that occurred for every clicker practice item in the transcripts was coded for evidence that the students engaged in collaborative reasoning while they were selecting an answer. Previous clickers studies that analyzed student interaction focused how much time individual students spent giving arguments and comments (Nielsen et al., 2014), but these coding categories did not capture whether arguments were co-constructed by multiple participants across multiple turns. Therefore, we drew upon the coding categories used in collaborative reasoning studies with children (Dong, Anderson, Lin, & Wu, 2009) and studies of collaborative critical reflection with university students (Higgins, Flower, & Petraglia, 1992; Neumann & McDonough, 2015). Reasoning was operationalized as talk to advance, support, or challenge a position. Specific types of reasoning include providing reasons for a claim, questioning the claims of others, and responding to challenges. To be considered collaborative, at least two students had to engage in reasoning, as shown in (1).

In this example, the students were deciding whether the verb in the sentence *my office needs a new secretary* was transitive or intransitive. Both students participated in the reasoning, such as giving reasons, questioning the claims of others, and responding to challenges.

(1) Collaborative reasoning[1]

S1: It's intransitive.
S2: That's transitive.
S1: It's transitive?
S2: Because there's a noun phrase *a new secretary* but there's no preposition right so it's like it's directly … it needs what? A new secretary so transitive.
S1: Okay so transitive things they need prepositions?
S2: No intransitive things either have nothing or prepositional … but transitive means a noun that's not prepositional phrase.
S1: Okay can-let me just write this down cause it's very con—
S2: —confusing yeah.
S1: So transitive it takes like a direct object like.
S2: Okay so intransitive it needs nothing or preposition.

If only one student engaged in reasoning and the other student(s) simply acknowledged the information, then the discussion was coded as individual reasoning. This type of interaction is illustrated in (2), where the students were identifying the function of the prepositional phrase *on eBay* in the sentence *she sold a photo of Nicki Minaj on eBay*. Although there is evidence of reasoning in that S2 provides reasons to support her claim, S1 simply acknowledges the information and does not engage in any reasoning.

(2) Individual reasoning

S1: It's an adjective?
S2: It's an adjective because it's about the photo and on eBay … so like you could say on eBay she sold a photo of Nicki Minaj … like you can say because on eBay is just saying like when she did it … like it describes more the verb like she sold it on eBay you know?
S1: Oh.
S2: You get it?
S1: Okay.

Finally, discussions that did not include any reasoning elements were coded as no reasoning. These included student talk in which one student stated an answer and another immediately accepted it, as shown in (3). These students were discussing the function of the prepositional phrase *of Nicki Minaj*, but S1 simply stated the answer and S2 agreed. Discussions in which one student asked for an answer and a peer provided it without any explanation were also coded as no reasoning.

(3) No reasoning

S1: Oh it's I think it's adjective.
S2: Yeah it's an adjective.
S1: Yeah.

In addition to coding the nature of student talk, the outcome of their discussions was coded for accuracy. Each discussion was classified as accurate if the students selected the correct answer choice (4), and inaccurate if they selected a distractor (5). A third coding category of other (6) was used for discussions which remained unanswered, the students guessed, a student accidentally clicked on the wrong answer choice, or it wasn't clear which answer they selected.

(4) Accurate answer: (SS discussing *the stapler fell into the wastebasket*)

S1: the stapler fell that's intransitive
S2: yes

(5) Inaccurate answer: (SS discussing *Kenji skied down the mountain*; correct answer is 2)

S1: Oh no it could be two … it could be two or four … because it could be like *ski down* that could be the verb.
S2: Yeah it can.
S1: But I feel I think it maybe four … I'm gonna put four.
S2: Yeah this is a hard one.

[1] For all examples, the capitalization and punctuation conventions of written language have been used, but pauses are indicated by an ellipsis, self-corrections by a single dash, and interruptions by a double dash.

(6) Other
   a. Accidental click on wrong answer
      S1: Oh no … oops I put five.
   b. Not clear what answer was selected
      T: Ok so you have 5 more seconds.
      S1: Oh my gosh oh my gosh click something.
      S2: Click something.
      S3: Just click anything.
   c. No resolution (SS discussing *the stapler fell into the wastebasket*)
      S1: I think it's intransitive.
      S2: No it is transitive.
      S1: Fell.
      S2: I think it's transitive. I might be wrong though.
      S1: I don't know.

The transcripts were coded by research assistants following training and practice coding with the first researcher, and interrater reliability was calculated on a subset of the data (20%). Cohen's kappa was .76 for reasoning and .87 for accuracy. Disagreements were resolved by the first researcher and included in the analysis.

3. Results

The dataset consisted of 498 transcribed conversations in which students discussed a clicker item. As shown in Table 1, the class periods in which students shared clickers had more discussions (290) than the class periods when the students had individual clickers (208), even though there were more practice items provided for the individual clicker classes. Across the four classes, the practice items required linguistic analysis at the word, phrase, clause, and sentence levels. The amount of time the students spent discussing each item varied, with variation reflecting item difficulty, knowledge of the target structure, presence of reasoning, and occurrence of disagreements. Although discussions in which there was no reasoning were quite short (e.g., 20 s), collaborative reasoning discussions tended to be longer (e.g., 2–3 min).

3.1. Clicker use and collaborative learning

The first research question asked whether shared clicker use facilitated collaborative learning, which was operationalized as collaborative reasoning and accurate answering. Table 2 provides the distribution of reasoning by clicker use. For the conversations when the students shared clickers, 38% (111/290) contained collaborative reasoning and 30% (86/290) had individual reasoning, while 32% (93/290) did not involve any reasoning. In contrast, during the conversations when the students had individual clickers, only 23% (48/208) contained collaborative reasoning and 28% (59/208) had individual reasoning, with nearly half (48%, 101/208) without any reasoning.

Table 1
Student conversations by class.

Week	Clicker use	Topic	Practice items	Conversations
4	Shared	Verb types	4	68
		Phrase types	3	51
		Sentence types	3 (10)	51 (sum = 170)
6	Individual	Phrases/clauses	3	30
		Sentence types	7 (10)	70 (sum = 100)
10	Shared	Verb tenses	5	75
		Reported speech	3 (8)	45 (sum = 120)
12	Individual	Apostrophe	5	39
		Articles	6	27
		Nouns	2	10
		Pronouns	6 (19)	32 (sum = 108)

Table 2
Reasoning by clicker use.

	Reasoning		
	Collaborative	Individual	None
Shared clickers (n = 290)	111 (38%)	86 (30%)	93 (32%)
Individual clickers (n = 208)	48 (23%)	59 (28%)	101 (49%)

To test the relationship between clicker use and reasoning, a Pearson chi-square test was carried out. The test revealed a significant relationship between clicker use and reasoning: χ^2 (2, 498) = 17.29, p = .001, w = .19. Analysis of the adjusted standardized residuals (Haberman, 1973) located significance with the relationships between clicker use and a) collaborative reasoning and b) no reasoning. Shared clicker use resulted in greater than expected occurrence of collaborative reasoning (3.6) and fewer than expected instances of no reasoning (−3.7). In contrast, individual clicker use was associated with less than expected collaborative reasoning (−3.6), and greater than expected instances of no reasoning (3.6). There was no significant relationships involving clicker use and individual reasoning. Put simply, when students shared clickers, they were more likely to engage in collaborative reasoning; however, when they had individual clickers, they were less likely to co-articulate reasons.

In terms of the accuracy of the students' answers, the distribution of answers by clicker use is shown in Table 3. As mentioned previously, the category "other" was used for conversations in which the students' answer choice could not be determined (i.e., they did not articulate which answer they chose or did not reach consensus) or they accidentally selected the wrong answer. When the students shared clickers, 63% (183/290) of their discussions resulted in the correct answer choice, while 17% (49/290) were incorrect and 20% (58/290) were classified as other. However, when the students had individual clickers, only 44% (91/208) of their discussions resulted in the correct answer, while 14% (30/208) were incorrect and 42% (87/208) were classified as other.

A Pearson chi-square test revealed a significant relationship between clicker use and accuracy: χ^2 (2, 498) = 28.53, p = .001, w = .24. The adjusted standardized residuals indicated that the significant relationships were between clicker use with correct and other answers. Shared clicker use resulted in greater than expected correct answers (4.3) and fewer than expected other answers (−5.3). In contrast, individual clicker use was associated with fewer than expected correct answers (−4.3), and greater than expected other answers (5.3). There was no significant relationships involving clicker use and incorrect answers. In sum, when students shared clickers, they were more likely to select the correct answer.

3.2. Students' perceptions about clicker use

The second research question investigated the students' perceptions of shared and individual clicker use. In terms of the students' views toward the class at the beginning of the semester, their responses on the initial questionnaire indicated that they had an overall positive attitude, with a mean of 3.98 (SD = .58) for questions about their interest, confidence, workload, and the usefulness of the material; however, they reported that it was somewhat true that they were only taking the course because it was required (M = 2.75, SD = 1.31). In terms of their preference for learning activities, they rated traditional activities (listening to the teacher explain and doing individual practice activities) higher (M = 4.26, SD = .56) than peer collaboration activities, such as doing practice activities in groups and comparing answer with their peers (M = 3.50, SD = .88).

On the questionnaires administered after the four classes with clicker activities, the students' perceptions about their usefulness for helping them understand the grammar points and get feedback, along with their general enjoyment were similar regardless of whether they had individual or shared clickers, as shown in Table 4. However, there were differences in terms of their preference for collaborative or individual clicker use. Following the individual clicker activities, the students agreed that they would have preferred to work collaboratively (M = 2.60, SD = 1.17). However, after the shared clicker activities, the students did not agree that they would have preferred to work individually (M = 1.85, SD = 1.10). A Wilcoxon signed-ranks test indicated that the difference was significant: Z = 2.86, p = .004, d = .66.

On the exit questionnaire completed at the end of the semester, the students indicated that clicker practice activities were more enjoyable (M = 4.47, SD = .77) and useful (M = 3.92, SD = 1.11) than practicing without clickers. In terms of why they

Table 3
Answers by clicker use.

	Answers		
	Correct	Incorrect	Other
Shared clickers (n = 290)	183 (63%)	49 (17%)	58 (20%)
Individual clickers (n = 208)	91 (44%)	30 (14%)	87 (42%)

Table 4
Perceptions of shared and individual clicker use.

	Shared clickers		Individual clickers	
	M	SD	M	SD
Understood grammar points	4.34	.65	4.32	.70
Received feedback	4.47	.70	4.40	.60
Enjoyed using clickers	4.52	.82	4.50	.67

liked clickers, they had positive reactions to the anonymity of their own answers ($M = 4.11$, $SD = 1.17$) and the ability to see everyone's answers ($M = 3.61$, $SD = 1.31$). When asked if individual clicker activities would have been preferable, the students indicated low levels of agreement ($M = 2.50$, $SD = 1.24$). However, they agreed that usefulness of the shared clicker activities was dependent on having a good partner to work with ($M = 3.19$, $SD = 1.41$).

4. Discussion

To summarize the findings, analysis of the students' interactions while answering clicker questions about English grammar indicated that they were more likely to engage in collaborative reasoning when they shared clickers, but more likely to answer without expressing any reasons for their choices when they had individual clickers. Furthermore, the students' answers were more accurate when they shared clickers. Thus, the findings confirm previous studies that reported positive findings for clicker activities involving peer discussion (Crouch & Mazur, 2001; Duncan, 2005; Jones et al., 2012; Mazur, 1997 Nicol & Boyle, 2003). Although the students were encouraged to discuss their answers with their peers for all clicker activities, their interactions contained greater collaborative reasoning and resulted in more accurate answers when they shared clickers. The findings suggest that students engaged in the co-construction of meaning when asked to reach consensus and jointly click in, with their collaboration resulting in more accurate answers. Interestingly, the occurrence of individual reasoning, which like peer teaching (Foot et al., 1990, as cited in Gachago et al., 2010), involved one student providing reasons for an answer choice while the other students listened, did not differ by clicker use.

In terms of their perceptions about the clicker use, the students reported positive reactions to both shared and individual clicker activities. Although previous studies have not compared individual and shared clicker use, a previous study in which students were required to share clickers reported that most students would have preferred individual clickers (Gachago et al., 2010). In contrast, these students reported a preference for shared clicker activities, even though their perceptions about the benefits of clicker activities and their enjoyment of them did not differ based on individual or shared clicker use. However, they did acknowledge the importance of having a good partner during shared clicker activities. Example (7) illustrates the collaborative reasoning that occurred when students engaged in the activity and worked together to reach consensus. The students were discussing the context in which the past progressive verb form was not used: 1) a habitual event in the past [correct], 2) an action in progress when another event occurred, 3) making a request more polite, or 4) something in progress at a specific time in the past.

(7) Shared clicker with collaborative reasoning and accurate answer
S3: Ah I know two is right.
S1: Two is right yeah.
S3: Three is right I was wondering is right.
S1: Yeah.
S3: Four is right.
S2: Something in progress at a specific time in the past.
S3: Because when the phone rang–
S2: –It was–
S3: –The phone was ringing I was in the shower when the phone rang but if you say the phone rang–
S1: –While I was in the shower.
S3: You didn't get in the shower because the phone rang.
S1: Something in progress at a specific time in the past I was writing my exam though.
S2: I think four is right no? It's for me four is right.
S1: What's one?
S2: Habitual.
S3: Habitual is I'm writing.
S2: Making a request.
S1: No because you would say I walk my dog every day you wouldn't say I was walking my dog.
S3: I walk my dog.
S1: Yeah in the past but you wouldn't say I was walking my dog every day.
S3: So that's wrong.
S1: So it's wrong so number one is wrong.
S3: Yeah.
S1: We all agree?
S2: Yes.
S1: Ok.

As (7) illustrates, all three students participated in the discussion by giving reasons, generating sentences to illustrate the usages of past progressive, and justifying for their answers. In the end, they reach consensus and select the correct answer. In contrast, when the two students in (8) answered the same question, they engaged in little collaborative reasoning and narrowed down the choice to two options, both of which were incorrect. For this item, after S1 suggested narrowing the option choices, S2 declined to engage and simply stated that she did not know the answer.

(8) Shared clicker with inaccurate answer

S1: Making a request more polite?
S2: I was hoping … it's more polite than I hope.
S1: I was going to this event, this event happens, an action happening when another action … another shorter event occurs what? Something in progress at a specific time in the past, ok number two then? I'm in debate between two and three.
S2: I've no clue.
S1: Sorry?
S2: I can't think.

Although shared clicker activities elicited more collaborative reasoning (38%) than individual clicker activities (23%), examples (7) and (8) highlight the variation in reasoning and accuracy that occurred during shared clicker activities and illustrate the students' perceptions about having a "good" partner. Despite this variation, however, the students answered more accurately when they shared clickers (63%) than when they had individual clickers (44%). This suggests that the outcome of shared clicker use was beneficial, even if the process by which the students selected the answer did not always reflect the co-construction of knowledge.

Also related to the co-construction of knowledge, as mentioned previously, the amount of individual reasoning was similar regardless of whether the students shared (30%) or had individual clickers (28%). This indicates that the tendency for one student to explain answers to other students who do not participate in the reasoning process, which has been referred to as peer teaching, may be unaffected by clicker use. Nielsen and colleagues (Nielsen et al., 2014) also reported that individual students may dominate conversation during clicker activities, although there was a more equitable distribution of participation when students had time to individually consider their answers before peer discussion. In the individual clicker activity shown in (9), the students were analyzing sentences from country music lyrics and had to identify the correct sentence type for *I've been flushed from the bathroom of your heart* from the following options: 1) simple [correct], 2) compound, 3) complex, and 4) I can't answer because I'm crying too hard. As illustrated in (9), S2 gives the reasons for the correct answer and S1 repeats them. Although their interaction does not reflect the co-construction of knowledge, S1 may benefit from hearing S2's explanation and restating it. Similarly, although S2 does not gain new information from the discussion, he may benefit from giving reasons for the answer and confirming S1's understanding.

(9) Individual reasoning with accurate answer

S2: I've been flushed from the bathroom of your heart I would say simple … because I've been there's only one verb.
S1: There's only one verb?
S2: Yeah.
S1: So only one subject one verb sentence in the sentence simple.
S2: Yeah.

While it was beyond the scope of the current study to compare the longer-term learning outcomes generated by individual and collaborative reasoning, future research should investigate how patterns of interaction affect subsequent accuracy and transfer of knowledge.

4.1. Pedagogical implications

As researchers have highlighted, there are a number of pedagogical practices that can be augmented with clickers (e.g., Hoekstra & Mollburn, 2012). They may wish to receive immediate feedback on whether their students understand a particular concept, attract students' attention during lectures, or foster collaborative learning. Researchers have argued that while technology can help achieve instructional goals, simply adopting technology does not ensure that those goals will be met (e.g., Kirkwood & Price, 2005) and the mere use of clickers may not be sufficient for achieving higher levels of collaboration (Cheong et al., 2012). For this reason, instructors should be clear about why they are using clickers, and adjust their way of using them accordingly. For example, if an instructor is using clickers to gauge students' understanding of a concept, assigning individual clickers may provide greater insight into their performance. However, for instructors who are

using clickers to promote collaborative learning, asking students to share clickers may increase their engagement in joint reasoning.

Although shared clickers facilitated collaborative reasoning, the number of discussions without any collaborative reasoning was relatively high in both conditions (62% for shared clickers and 77% for individual clickers). It is difficult to know why this was case, and a number of factors were likely involved, such as the difficulty of the questions, the rapport of the learners, and the culture of the lecture class. Instructors should consider both the structure and implementation of clicker activities in order to maximize the likelihood of collaborative reasoning occurring. In particular, item difficulty may play an important role in whether students engage in collaborative reasoning. For example, when the students shared clickers they were able to answer 57/290 (20%) of the items correctly without engaging in any reasoning, which suggests that the items were not sufficiently difficult to require reasoning. In contrast, during the individual clicker activities, the students answered only 32/208 items (15%) correctly without any reasoning before clicking in. By ensuring that the items are sufficiently difficult and cannot be deduced using test-taking strategies, instructors may elicit greater levels of collaborative reasoning.

Another important pedagogical consideration for instructors concerns student preferences for clicker activities. A study which required that students share clickers found that 80% would have preferred to have their own clicker (Gachago et al., 2010). However, the findings of the current study indicated that when students had the chance to compare shared and individual clicker use, they preferred shared clickers. If students express displeasure with shared clicker use, it may be beneficial for instructors to incorporate individual clicker use into their instructional routine, so that students can experience both procedures. However, given the finding that students were more likely to choose the correct answer when sharing clickers, having students share clickers during classes with challenging concepts may encourage them to engage in collaborative reasoning and reply more accurately.

4.2. Limitations and future research

There are a number of limitations in this study that should be addressed in future research. First, while the findings revealed that students more likely to select the correct answer when sharing clickers, the topics or difficulty of the questions were not strictly controlled across the class periods. For this reason, this finding must be interpreted with caution as it is possible that the individual clicker questions were inherently more difficult than the collaborative items. It is also possible that the number of discussion tasks used in each class impacted collaborative reasoning. The last class with clicker activities had many more items than the previous classes, which may have led to fatigue and negatively impacted the students' engagement in collaborative learning. It is also possible that the question types impacted students' engagement in collaborative learning, as some items provided more response options than others. Another limitation of this study is the unequal distribution of male and female participants (40 out of 44 participants were women), as previous studies have found gender differences with clicker use. For example, Kang and colleagues (Kang, Lundeberg, Wolter, delMas, & Herreid, 2012) compared traditional lectures with clicker activities in introductory biology classes and found that women performed equally well or better when using clickers, whereas men performed better with lecture-based instruction. It is possible that current findings reflect the greater number of female participants than male participants. Future research studies could compare the effectiveness of individual and shared clicker with a more balanced participant pool in order to determine whether gender acts as a moderating variable for students' perceptions or performance during shared clicker activities.

Future research might also look beyond simply assigning shared or individual clickers at the beginning of each class period. For example, Crouch and Mazur's (2001) peer instruction approach includes a combination of individual clicker use and peer discussion with re-voting to improve student accuracy. Comparative studies to identify the learning processes and outcomes associated with peer instruction versus shared clicker use can shed light on the amount and type of collaborative reasoning that occurs through each approach. Allowing students to decide whether they would prefer to have individual or shared clickers may help instructors of classes with large enrollments to accommodate students' individual differences. Although clickers show promise as a tool for increasing collaboration and student engagement, more research is needed to identify clicker techniques that maximize their benefits, help instructors accomplish their instructional goals, and promote student learning.

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Appendix A

Initial questionnaire

Instructions: For each statement below, indicate how much you agree or disagree.

	Not true	Slightly true	Moderately true	Mostly true	Very true
Based on the course outline and textbook, this class has very little in it that captures my attention.	1	2	3	4	5
Comparing answers to practice activities with my classmates will help me learn.	1	2	3	4	5
I feel confident that I will do well in this course.	1	2	3	4	5
Listening to the teacher explain English grammar will help me learn.	1	2	3	4	5
I will have to work too hard to succeed in this course.	1	2	3	4	5
Doing practice activities by myself during class will help me learn.	1	2	3	4	5
The things I will learn in the course will be useful to me.	1	2	3	4	5
Doing practice activities in pairs or small groups with my classmates will help me learn.	1	2	3	4	5
Using technology in this course will not help me learn.	1	2	3	4	5
I would take this course even if it wasn't a requirement.	1	2	3	4	5

Appendix B

Post-clicker questionnaire

Instructions: For each statement below, indicate how much you agree or disagree.

	Not true	Slightly true	Moderately true	Mostly true	Very true
The practice activities helped me understand today's grammar points.	1	2	3	4	5
I enjoy using clickers for practice activities.	1	2	3	4	5
Using clickers for practice activities is useful for getting feedback.	1	2	3	4	5
Listening to the instructor explain grammar and give examples is more helpful than doing practice activities.	1	2	3	4	5
I would have rather done the practice activities by myself.*	1	2	3	4	5

*Note: This question was worded as “I would have rather done the practice activities with a partner” during classes when clicker activities were done individually.

Appendix C

Final questionnaire

Instructions. For each statement below, indicate how much you agree or disagree.

	Not true	Slightly true	Moderately true	Mostly true	Very true
Doing practice activities with a partner was only useful if I had a good partner.	1	2	3	4	5
Clicker activities were better for some practice activities than others.	1	2	3	4	5
A good thing about clickers was that I could see everyone's answers.	1	2	3	4	5
We spent too much time in class doing practice activities.	1	2	3	4	5
A good thing about clickers was that my answers were anonymous.	1	2	3	4	5
Practice activities with clickers were more fun than practice activities without clickers	1	2	3	4	5
Practice activities with clickers were more useful than activities without clickers.	1	2	3	4	5
Working by myself was a better match for my personality and learning style.	1	2	3	4	5

Appendix D

Prompts for clicker activities

Transcript (1).

Question: Is the verb transitive or intransitive?
Target Sentence: My office needs a new secretary.
Options:

1. Transitive (correct)
2. Intransitive
3. Who knows?

Transcript (2) and (3).

Question: For the following sentences identify whether the prepositional phrase is and adjective prepositional phrase or an adverb prepositional phrase
Target Sentence: She sold a photo of Nicki Minaj on eBay.
Options:

1. Both are both adj. PPs
2. They are both adv. PPs
3. The first is an adj. PP and the second is an adv. PP (correct)
4. The first is an adv. PP and the second is an adj. PP
5. %$&%@(&#&@!

Transcript (4) and (6c).

Question: Is the verb transitive or intransitive?
Target Sentence: The stapler fell into the wastebasket.
Options:

1. Transitive
2. Intransitive (correct)
3. Whatever…

Transcript (5), (6a), and (6b).

Question: What best represents the following sentences?

Remember
S = subject
O = object
V = verb
A = adverbial

Target Sentence: Kenji skied down the mountain.
Options:

1. SV
2. SVO
3. SVA (correct)
4. SVAO
5. SVSSVVOOOAOAA…the voices in my head are angry!!!!!

Transcript (7) and (8).

Question: Which of the following is not true
Target Sentence: We often use the past progressive for…
Options:

1. …a habitual event in the past. (correct)
2. …an action happening when another shorter event occurs.
3. …making a request more polite.
4. …something in progress at a specific time in the past.

Transcript (9).

Question: Is the song title a simple, compound, or complex sentence?
Target Sentence: I've been flushed from the bathroom of your heart.
Options:

1. Simple (correct)
2. Compound
3. Complex
4. I can't answer because I am crying too hard.

References

Beekes, W. (2006). The "Millionaire" method for encouraging participation. *Active Learning in Higher Education, 7*(1), 25–36.
Bergtrom, G. (2006). Clicker sets as learning objects. *Interdisciplinary Journal of Knowledge and Learning Objects, 2*, 105–110.
Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance. *Computers & Education, 62*, 102–110.
Brufee, K. (1999). *Collaborative learning: Higher education, interdependence and the authority of knowledge*. Baltimore: Johns Hopkins University Press.
Caldwell, J. (2007). Clickers in the large classroom: current research and best-practice tips. *Life Sciences Education, 6*(1), 9.
Cardoso, W. (2011). Learning a foreign language with a learner response system: the student's perspective. *Computer Assisted Language Learning, 24*, 393–417.
Caulfield, S., & Hodges Persell, C. (2006). Teaching social science reasoning and quantitative literacy: the role of collaborative groups. *Teaching Sociology, 34*(1), 39–53.
Cheesman, E., Winograd, G., & Wehrman, J. (2010). Clickers in teacher education: student perceptions by age and gender. *Journal of Technology and Teacher Education, 18*, 35–55.
Cheong, C., Bruno, V., & Cheong, F. (2012). Designing a mobile-app-based collaborative learning system. *Journal of Information Technology Education, 11*, 97–119.
Crouch, C. H., & Mazur, E. (2001). Peer instruction: ten years of experience and results. *American Journal of Physics, 69*, 970–977.
Dong, T., Anderson, R., Lin, T., & Wu, X. (2009). Concurrent student-managed discussions in a large class. *International Journal of Educational Research, 48*, 352–367.
Duncan, D. (2005). *Clickers in the classroom: How to enhance science teaching using classroom response systems*. San Francisco: Pearson Addison-Wesley.
Elliott, C. (2003). Using a personal response system in economics teaching. *International Review of Economics Education, 1*(1), 80–86.
Gachago, D., Morris, A., & Simon, E. (2010). Engagement levels in a graphic design clicker class: students' perceptions around attention. *Journal of Information Technology Education, 10*, 253–269.
Gokhale, A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education, 7*(1), 22–30.
Haberman, S. (1973). The analysis of residuals in cross-classified tables. *Biometrics, 29*, 205–220.
Higgins, L., Flower, L., & Petraglia, J. (1992). Planning text together. *Written Communication, 9*(1), 48–84.
Hoekstra, A., & Mollburn, S. (2012). How clicker use facilitates existing pedagogical practices in higher education: data from interdisciplinary research on student response systems. *Learning, Media, and Technology, 37*, 303–320.
Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Cooperative learning returns to college: what evidence is there that it works? *Change, 20*(4), 27–35.
Jones, M. E., Antonenko, P. D., & Greenwood, C. M. (2012). The impact of collaborative and individualized student response system strategies on learner motivation, metacognition, and knowledge transfer. *Journal of Computer Assisted Learning, 28*, 477–487.
Kang, H., Lundeberg, M., Wolter, B., delMas, R., & Herreid, C. (2012). Gender differences in student performance in large lecture classrooms using personal response systems ('clickers') with narrative case studies. *Learning, Media and Technology, 37*, 53–76.
Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: a review of the literature. *Computers & Education, 53*, 819–827.
Kirkwood, A., & Price, L. (2005). Learners and learning in the twenty-first century: what do we know about students' attitudes towards and experiences of information and communication technologies that will help us design courses? *Studies in Higher Education, 30*, 257–274.
Lucas, A. (2009). Using peer instruction and I-clickers to enhance student participation in calculus. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies, 19*, 219–231.
Mazur, E. (1997). *Peer instruction: A user's manual*. Saddle River, NJ: Prentice Hall.
Michaelson, L. K., Knight, A. B., & Fink, L. D. (2004). *Team-based learning: A transforming use of small groups in college teaching*. Sterling, VA: Stylus.
Milner-Bolotin, M., Antimirova, T., & Petrov, A. (2010). Clickers beyond the first-year science classroom. *Journal of College Science Teaching, 40*(2), 14–18.
Neumann, H., & McDonough, K. (2015). Exploring student interaction during collaborative prewriting discussions and its relationship to L2 writing. *Journal of Second Language Writing, 27*, 84–104.
Nicol, D., & Boyle, J. (2003). Peer instruction versus class-wide discussion in large classes: a comparison of two interaction methods in the wired classroom. *Studies of Higher Education, 28*, 457–473.
Nielsen, K. L., Hansen, G., & Stav, J. B. (2014). How the initial thinking period affects student argumentation during peer instruction: students' experiences versus observations. *Studies in Higher Education*. http://dx.doi.org/10.1080/03075079.2014.915300. Advance online publication.

Panitz, T. (1999). *Collaborative versus cooperative learning—a comparison of the two concepts which will help us understand the underlying nature of interactive learning*. Retrieved from ERIC database. (ED448443).
Resta, P., & Laferriere, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review, 19*, 65–83.
Serafini, E. (2013). Learner perceptions of clickers as a source of feedback in the classroom. In K. McDonough, & A. Mackey (Eds.), *Second language interaction in diverse educational contexts* (pp. 209–224). Amsterdam: John Benjamins.
Sevian, H., & Robinson, W. (2011). Clickers promote learning in all kinds of classes—Small and large, graduate and undergraduate, lecture and lab. *Journal of College Science Teaching, 40*(3), 14–18.
Slavin, R. E., & Cooper, R. (1999). Improving intergroup relations: lessons learned from cooperative learning programs. *Journal of Social Issues, 55*(4), 647–663.
Slusser, S., & Erickson, R. (2006). Group quizzes: an extension of the collaborative learning process. *Teaching Sociology, 34*, 249–262.
Smith, M. K., Wood, W. B., Adams, W. K., Wieman, C., Knight, J. K., Guild, N., et al. (2009). Why peer discussion improves student performance on in-class concept questions. *Science, 323*, 122–124.
Trees, A., & Jackson, M. (2007). The learning environment in clicker classrooms: student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media, & Technology, 32*, 21–40.
Wolfe, A. (2012). Implementing collaborative learning methods in the political science classroom. *Journal of Political Science Education, 8*, 420–432.