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Seanice Beard 
University of Detroit Mercy, USA

Eva N. Nyutu 
University of Detroit Mercy, USA

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Do Gender Differences Influence Students' Perceptions of Bring Your Own Device (BYOD) Clickers in an Introductory Biology Course?

Seanice Beard, Eva N. Nyutu

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Abstract

The use of clickers in the lecture classroom has increased in recent years. Clickers have been widely used to improve teaching effectiveness in various lecture classroom settings. Most introductory biology courses are taught using direct instruction. One of the ways that students may be engaged in the lecture classrooms is by using a clicker. Clickers have been linked to several positive outcomes for students. Although clickers have been used in several prior studies, few studies have explicitly focused on BYOD clickers (smartphones, tablets, laptops). This study examined the influence of gender on students' perceptions of using BYOD clickers in an introductory biology course at a Midwestern private college. The findings suggest that male students have more positive perceptions about using BYOD clickers than females in the introductory biology lecture. The BYOD clicker can foster active learning in the classroom and improve classroom experiences and perceptions for all students in biology and other STEM courses.

Introduction

Audience response systems, student response systems, personal response systems, interactive response systems, electronic response system, interactive response systems, classroom response systems, and electronic voting systems are all also known as clickers (Chamber, 2020; Han and Finkelstein, 2013; Kay and Lesage, 2009; Oigara and Keengwe, 2013). Clickers have been used in the classroom for over 50 years, whereas earlier clickers used infrared technology, which was then replaced by radio frequency-enabled devices (Abrahamson, 2006; Judson and Sawada, 2002, 2006). Recently clickers have taken many forms, including wireless devices, and web-based programs, like TopHat™ response systems, which provide similar benefits to clickers with increased functionality (Tophatmonocle Corp, 2017).

Today, contemporary clickers, available through providers like Top Hat, allow students to use their mobile devices (smartphone, tablet, laptop, and Chromebook) to respond to questions that the instructor posts within a PowerPoint as part of daily lectures or as a review from previous lectures (Tophatmonocle Corp, 2017). The increased ownership by students of smartphones and faster wireless data connections gave rise to the Bring Your Own Device (BYOD). The BYOD technology has gained popularity as a flexible and more cost-effective way for instructors to engage with students in the classroom and improve learning outcomes (Chen, Chen, and Liu, 2020).

During the lecture presentation, students are prompted to answer questions using their response devices. The student responses are then submitted via the software portal, where they are immediately analyzed, and a histogram shows the responses' distribution among the answer choices. This tool assesses student learning to provide the instructor with real-time feedback and promotes participation and engagement essential in active learning (Judson and Sawada, 2002; Ma, Steger, Doolittle, and Stewart, 2018; Niemeyer and Zewail-Foote, 2018). Therefore, the instructor can instantly decide if a topic needs to be reviewed or if the lecture can proceed, while the students can self-reflect on their understanding of the concept just covered (Cadwell, 2007; Ma, Steger, Doolittle, and Stewart, 2018; Niemeyer and Zewail-Foote, 2018). The TopHat™ allows the implementation of various question types, multiple-choice, multiple-response, fill-in-the-blank, matching, ordering, free-text response, and hot-spot (click-on-target) picture questions (Ma, Steger, Doolittle, and Stewart, 2018; Tophatmonocle Corp, 2017). Incorporating active learning pedagogies like clickers has been shown to generally improve learning for all students within science, technology, engineering, and math (STEM) courses (Naibert, Vaughan, Brevick, and Barbera, 2022).

Researchers have shown that students in introductory science, technology, engineering, and math (STEM) lectures are not engaged because most faculty (83%) in these gateway classrooms teach using direct instruction methods (Barnes, Marateo, and Ferris, 2007; Chung, Shel, and Kaiser, 2006; Herreid, 2010; Prensky, 2001a; Sevia and Robinson, 2011). However, faculty teaching large gateway STEM lecture courses have been shown to adopt clickers readily; around 21% of these faculty regularly use clickers in their courses (Niemeyer and Zewail-Foote, 2018). In large STEM gateway courses, clickers have been shown to improve exam scores and decrease failure rates for students (Caldwell, 2007; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, Wenderoth, 2014; Niemeyer and Zewail-Foote, 2018) enhance classroom interaction and active learning (Gauci, Dantas, Williams, and Kemm, 2009; Draper, Cargill, and Cutts 2002; Guthrie and Carlin 2004; Duncan 2006; Niemeyer and Zewail-Foote, 2018), critical thinking (Mollborn and Hoekstra 2010; Niemeyer and Zewail-Foote, 2018), peer interaction and cooperation (Crouch and Mazur 2001; English and Kitsantas 2013; Niemeyer and Zewail-Foote, 2018), real-time assessment and feedback (Greer and Heaney 2004; Niemeyer and Zewail-Foote, 2018), conceptual application (Hoekstra 2008; Niemeyer and Zewail-Foote, 2018), and transform the social and emotional environment of the classroom (Stowell and Nelson 2007; Hoekstra 2008; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, and Wenderoth, 2014; Niemeyer and Zewail-Foote, 2018).

Since the use of clickers in college, undergraduate STEM gateway courses have been continually increasing (Emenike and Holme, 2012; Trees and Jackson, 2007); it is important to examine how this pedagogy may differentially affect the perceptions of women and men within this gateway STEM courses. Given that these science classrooms include diverse students (e.g., students from different races, ethnicities, genders, and worldviews), how do these groups experience clickers differently (Chambers, 2020). Although clickers have been widely adopted (Gibbons, Laga, Leon, Villafañe, Stains, Murphy, and Raker, 2017; Niemeyer and Zewail-Foote, 2018), few studies have examined how clickers may differentially impact gender in undergraduate STEM classrooms (Gibbons, Laga, Leon, Villafañe, Stains, Murphy, and Raker, 2017; Hoekstra, 2008; Kang, Lundeberg, Wolter, delMas, and Herreid, 2012; King and Joshi, 2008; Wolter, Lundeberg, Kang, and Herreid, 2011; Niemeyer and Zewail-Foote, 2018; Welsh, 2012; Lorenzo, Crouch, and Mazur, 2006; MacGeorge, Homan,

Dunning, Elmore, Bodie, Evans, Khichadia, Lichti, Feng, and Geddes, 2008a. These studies showed mixed results; in some studies, females had positive perceptions of clickers as compared to males (Niemeyer and Zewail-Foote, 2018; King and Joshi, 2008; Kang et al., 2012; Welsh, 2012; Lorenzo, Crouch, and Mazur, 2006; Wolter, Lundeberg, Kang, and Herreid, 2011; MacGeorge et al., 2008a). Other studies showed that males had more positive perceptions of clickers than females (Gok, 2011). While in other studies, there was no gender difference in students' perceptions of clickers (Kiefer, 2013; Chambers, 2020; González-Espada and Bullock, 2007; Edmonds and Edmonds, 2008; Freeman and Blayney; 2005; Alanazi, 2021; Cheesman, Winograd, and Wehrman, 2010).

Despite general support for adopting clickers in large courses, gender effects of students' perceptions of BYOD clickers in medium-sized lecture courses are not well known. In order to promote effective and equitable learning, it is important to know whether clickers benefit male and female students equally or to a different degree. The overarching goal of this study is to describe the influence of gender on students' perceptions of BYOD clickers in an introductory biology lecture. Thus, the guiding research questions were:

R1: What are the differences/similarities between female and male students' perceptions of using clickers in an introductory general biology lecture?

R2: What reasons do female and male students give for their positive or negative use of clickers in an introductory general biology lecture?

Methodology

The clicker used during this study was a web-based platform called Top Hat (Tophatmonocle Corp, 2017). It connects to the students' mobile devices, such as smartphones, laptops, and tablets. The Top Hat platform does not require students to purchase clickers. Instead, they buy a license to use the software on their mobile devices. The price was \$20 per student for four months. In addition to clicker questions, the software can host all lecture materials, including presentations, text documents, and videos. Therefore, it is possible to quickly set up questions, move them within presentations if needed, and administer lectures entirely out of the Top Hat platform. Because a grade book function was included, each session had a unique Join Code. The instructor enabled Geofencing for each session to ensure that only students who were physically in attendance could participate. A student roster was linked from the Blackboard learning management system to the Top Hat platform, which enabled various functions such as summative assessments, segmentation of questions, targeted item analysis, attendance tracking, and certain gradebook items to sync at the discretion of the instructor. The Top Hat software allowed questions to be delivered multiple ways: during lectures, assigned homework, or for review.

At the beginning of the course, the instructor explained to the students that clicker questions would be used for summative assessment. Students were allowed to discuss the questions with their peers. The instructor also demonstrated how to use the clickers and posted a video from the Top Hat website on how to use clickers on the Blackboard course site. Throughout the course, the instructor used 5-10 clicker questions at the end of each chapter covered that allowed students to focus their attention and provide feedback on their comprehension of the material covered. The questions were conceptual and focused on the chapter's key concepts (Woelk, 2008; Beatty Gerace,

Leonard, and Dufresne, 2006). The questions were primarily taken from the Macmillan supplemental materials supplied within the textbook and test bank, and the course instructor designed some. The clicker questions were administered directly following the end of the chapter that had been covered. The students responded to questions using their own devices; various question types were utilized, multiple-choice and multiple-answer format, fill-in-the-blank, sorting/matching, free-response, and hot-spot (click-on-target) questions. When a question was presented, students had 2-3 minutes to discuss possible answers to the question with their immediate neighbours, come to a conclusion, and individually submit their answers. Afterward, the correct answer was displayed and explained by the instructor.

We implemented clickers into one section of our second-semester general biology course for undergraduate science majors and non-majors. The course section was taught by one of the researchers. The instructor used various pedagogical techniques in addition to the clicker, including group work, lecture, and facilitated discussion. The percentage of clicker questions answered correctly accounted for 5% of the student's total grades. Students were required to register their clickers in the first week of classes, and throughout the semester, the clickers were used on average in two of the three 50 min lectures each week about (17 times. during the semester). The questions consisted of five to ten questions, with multiple choice, multiple answers, fill-in-the-blank, sorting/matching, free-response, hot-spot (click-on-target) questions, and true/false questions that covered the lecture content. The software registered a response when each student voted, and a histogram summarizing student responses was then displayed in real-time to the class along with the correct answer. If the histogram indicated incorrect student responses to the clicker question, the instructor followed up with further discussion on the topic. The responses were anonymous during the class session, but the individual answers were stored for later viewing by the instructor. The instructor compiled clicker scores for participation over the course of the semester and found that 72% of all clicker questions were answered correctly. A convenience sample (Creswell, 2014) was recruited from an appropriate course at a private Midwestern university, providing a rich mixture of students (Marshall and Rossman, 2014).

Human Subjects Institutional Review Board (HSIRB) approval was obtained. All the students were given one week to take the online clicker survey at the end of the semester. Students were informed that participating in the survey was anonymous and had no possible influence on their final course grades. A 14-item Likert scale survey was used to collect students' perceptions of clicker usage. The items were selected from two prior studies regarding students' perception of clicker usage (Graham, Tripp, Seawright, and Joeckel, 2007; Porter and Tousman, 2010). Participants were asked to indicate their level of agreement with each item using a 5-point scale, where 5 = strongly agree; 4 = agree; 3 = neither agree nor disagree; 2 = disagree, and 1 = strongly disagree. Two additional open-ended questions were asked to obtain qualitative narrative comments about the strengths and weaknesses of using clickers. All survey data were compiled and analyzed using the statistical tools available in IBM SPSS Statistics 27.

Student responses from 14 Likert-style survey questions related to the clicker were first converted to numeric values (e.g., strongly disagree = 1). Results for each survey question are reported as a mean value with standard deviation (SD). In addition, the percentage of those students who agreed (where "strongly agreed" and agreed"

are combined) was calculated for all respondents.

Results

All the students in this course were in their first year of college. They intended to pursue a major in pre-health (pre-medical, pre-dental, pre-veterinary, pre-nursing, pre-physician assistant, and pre-pharmacy). Students completed the questionnaires anonymously and voluntarily with a total sample population of 51 students, consisting of 14 men and 37 women. When survey answers regarding the clicker were averaged for all students, the cumulative mean score (3.96) indicated that our students had positive perceptions of the BYOD clickers. Interestingly, males (mean = 4.21) were found to have a more positive perception of the clickers than females (mean = 3.87).

Table 1. Comparison of Mean Response Scores to Survey Questions about Clicker Use by Females and Males

Questions	Mean Scores/Standard Deviation	
	Females	Males
I like the way clickers give instant feedback.	4.26/1.38	4.36/0.93
Clicker usage helped motivate me to be more prepared for class.	4.03/1.37	3.93/0.92
Clicker usage helped me to gauge my understanding of class content.	3.94/1.46	4.29/0.73
Discussion of the clicker answers helps me to clarify my knowledge about the subject	3.76/1.45	4.36/0.63
Being able to answer anonymously is important to me.	4.21/1.44	3.79/1.05
Clicker usage is a good way of helping me maintain concentration in class	4.00/1.43	4.29/0.61
Clickers help me to do better on quizzes and exams.	3.97/1.52	4.07/1.00
Clicker questions encourage me to be more engaged in the classroom process.	4.06/1.37	4.36/0.63
Clicker usage helped me participate in class.	4.15/1.37	4.36/0.63
Clicker usage helped make the learning experience more enjoyable.	3.79/1.39	4.14/0.77
Given two class sections that are the same in all other respects, I would take the one that uses the clicker	3.68/1.36	4.07/0.92
Overall, I have enjoyed using clickers.	3.79/1.33	4.21/0.70
I found the clickers easy to use.	4.25/1.03	4.50/0.65
I choose my answer to each clicker question carefully.	4.17/1.20	4.21/0.89

We examined individual questions from our survey for gender differences in student responses on questions related to learning perceptions, student engagement, and the overall classroom experience are shown in Table 1. Females were more positive about whether clicker usage helped motivate them to be more prepared for class (mean = 4.03 compared to 3.94 for males), and being able to answer with the clickers anonymously is important

(mean = 4.21 compared to 3.79 for males). The data (see Figure 1) indicate male students had a higher mean (4.36) than female students (4.26) about whether they liked the way clickers give instant feedback. Male students also had a higher mean score for whether clicker usage helped them gauge their understanding of class content (male mean = 4.29; female mean = 3.94). The survey showed male students had a higher mean (4.36) than female students (3.76) about how clicker answers helped them to clarify their knowledge about the subject. Students also reported that clicker usage is a good way of helping them maintain concentration in class (male mean = 4.29; female mean = 4.00).

Males also agree that clickers helped them to do better on quizzes and exams (mean = 4.07 compared to 3.97 for females). Men (mean = 4.36) were also much more likely than their female counterparts (mean = 4.06) to agree that clicker questions encouraged them to be more engaged in the classroom process. Males were more positive about clicker usage helped make their learning experience more enjoyable (mean = 4.14 compared to 3.79 for females). Men also agreed that given two class sections that are the same in all other respects, they would take the one that uses the clicker (mean = 4.07 compared to 3.68 for females). Men agreed they enjoyed using clickers (mean = 4.21 compared to 3.79 for females). Males (mean =4.50) also found the clickers easier to use than females (mean = 4.25). Finally, males (mean = 4.21) agreed that they chose their answer to each clicker question carefully compared to females (mean = 4.17).

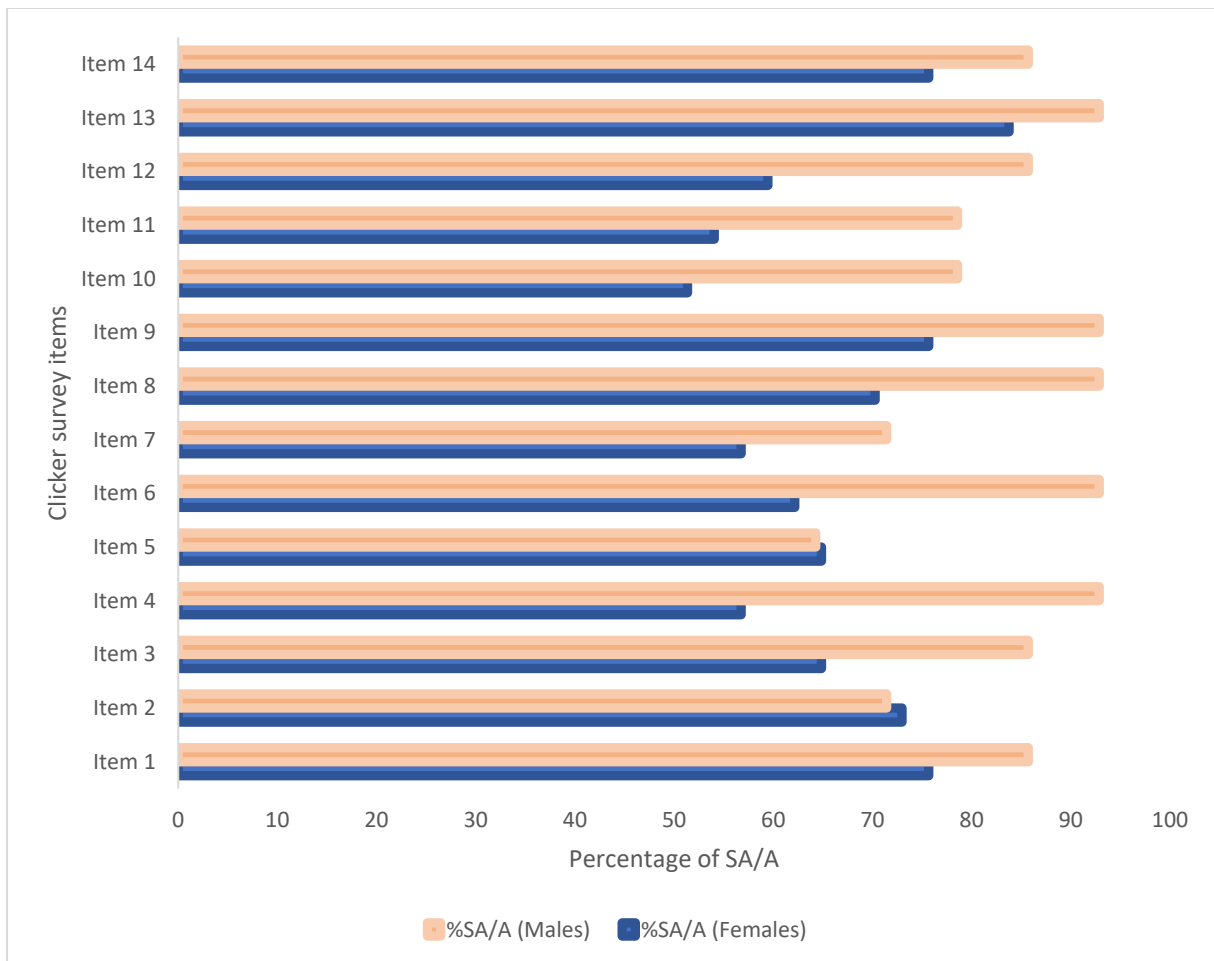


Figure 1. Student Responses to the Clicker Survey Items

Discussion and Conclusion

Overall, the students had generally positive perceptions of using BYOD clickers in our medium-sized undergraduate general biology course, similar to findings in large lecture courses (Niemeyer and Zewail-Foote, 2018; Caldwell, 2007; Chambers, 2020). Regardless of class size, the clicker provides the same overall benefits and is an effective tool to provide instant feedback, facilitate discussion, increase interactions, and actively engage students in the learning process. Interestingly, our results demonstrate that although our undergraduate students had favorable perceptions of using the clicker, men valued the technology to a greater extent. When looking at the trends in the means, males responded more positively to clickers on almost every question when compared to females. Although the means were not significantly different, it is compelling that the males consistently rated the instrument items higher except for two items. This seems to align with the prior work that noted males had more positive perceptions of clickers than females. Hoekstra (2009) performed a socio-cultural analysis of the effects of clickers in higher education. Her findings suggest that male students are more likely to work independently during clicker activities, while female students prefer to work in groups for clicker questions. Also, males were much more likely to mention or emphasize appreciating clicker questions as an opportunity to self-test.

Similarly, Gok (2011) reported a significant gender difference, with men having more positive attitudes about clickers. According to Goswami and Dutta (2016) and Cai, Fan, and Du (2017), males tend to have more favorable attitudes toward technology use; they are viewed to be more technologically adept than women. We postulated that it was not the BYOD clicker itself that males favored but rather that they preferred how the clicker facilitated classroom discussion and interaction. In this general biology course, males favored active-learning strategies, including the clicker, and perceived its use beneficial to their academic performance. The male students may view the clicker more positively than females as a consequence of changes to the classroom learning environment that occurred with the introduction of the BYOD clicker technology. Our results strongly support this explanation since we observed the greatest gender differences in responses to general questions about how the clicker affected the class experience.

Our students commented on the benefits of BYOD clickers. Most males felt that the instantaneous feedback helped them gauge their understanding of the material and prepare for exams and quizzes. Some drawbacks that the males stated were technological, where answers were not submitted on time, and the cost of the technology. Most females stated that the benefits of the BYOD clickers are they help gauge the understanding of the material in class and prepare for their exams and quizzes. Some of the drawbacks were that the time it took to answer the questions was not enough and the technological issues of using the clickers. Clickers do not gender discriminate, but it might be easier for one gender to understand a concept, and clicker use would be a good reinforcement for the learned concept (Lorenzo et al. 2006).

One benefit to using the clicker in medium-sized lecture classrooms is that it can effectively facilitate group interactions and peer instruction. Although our results demonstrate a gendered preference for clicker use in the introductory biology classroom, limitations to the study exist. We did not have a control group to compare students' perceptions of general biology in a course that utilized BYOD clickers with one that did not.

Additionally, the sample population of our study was small and consisted of only pre-health students. Finally, although our results indicate that male students preferred the BYOD clickers to a greater extent than their female peers, we do not know definitively why such a preference exists. Additional interviews or focus groups with male and female respondents could allow us to elucidate the reasons for differences in students' perceptions of using the BYOD clickers in the general biology course.

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Author Information

Seanice Beard

 <https://orcid.org/0000-0002-3508-4166>


Department of Biology

University of Detroit Mercy

Detroit

USA

Eva N. Nyutu

 [https:// orcid.org/0000-0002-9821-7587](https://orcid.org/0000-0002-9821-7587)

Department of Biology

University of Detroit Mercy

Detroit

USA

Contact e-mail: nyutuen@udmercy.edu

Appendix A. Clicker Survey

STUDENT DEMOGRAPHICS

Gender: _____ Male _____ Female

Academic Major (or intended major): _____

Directions

The following questionnaire contains 14 statements about your opinions in using clickers in class.

For each item, please choose an option that best describes your level of agreement or disagreement about the use of clickers.

Indicate your opinion by clicking on one bubble per item according to the following scale.

Only fill one bubble per item.

STRONGLY DISAGREE with the statement.



DISAGREE with the statement.



NO OPINION about the statement



AGREE with the statement.



STRONGLY AGREE with the statement



ITEMS		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I like the way clickers give instant feedback.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Clicker usage helped motivate me to be more prepared for class.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Clicker usage helped me to gauge my understanding of class content.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Discussion of the clicker answers helps me to clarify my knowledge about the subject.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Being able to answer anonymously is important to me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Clicker usage is a good way of helping me maintain concentration in class.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Clickers help me to do better on quizzes and exams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Clicker questions encourage me to be more engaged in the classroom process.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	Clicker usage helped me participate in class.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	Clicker usage helped make the learning experience more enjoyable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Given two class sections that are the same in all other respects, I would take the one that uses the clicker	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	Overall, I have enjoyed using clickers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	I found the clickers easy to use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14	I choose my answer to each clicker question carefully.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please write any additional comments regarding strengths of using clickers

Please write any additional comments regarding weaknesses of using clickers