ORIGINAL RESEARCH

Usability of a classroom response system in an online course: Testing of a smartphone-downloadable technology enhanced learning tool for distance education

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ABSTRACT

Background and objective: Classroom response systems (CRS) have been used in higher education since the 1990s to enhance student learning and engagement. It began with portable "TV remote control-looking" devices that students used in class to answer questions posed by the professor. Aggregated responses are available instantaneously and projected on the screen to serve as a feedback mechanism for the professor and students to gauge learning, potentially prompt further review of the topics, or inspire further discussion. Companies which produce CRS tools are beginning to develop apps to allow students to use their own technology mobile devices during similar learning activities. Many educational institutions are increasingly offering distance education courses and programs, yet little is currently known about the effectiveness of CRS integration into online courses. This usability study was conducted to determine whether a technology enhanced learning tool, specifically a CRS that can be downloaded to one's smartphone, would be suitable for adoption in online classes in one particular suburban university in New York.

Methods: The study is a mixed method, one group, pretest/posttest descriptive design. Convenience sampling (n = 48) was used to engage students enrolled in an online nursing course during their first semester in a master's degree program. A five-point Likert scale was designed for respondents to rate 21 statements in terms of their degree of agreement (with 5 being "strongly agree" and 1 being "strongly disagree"). The statements included descriptors of the three usability domains (functionality, support and effectiveness) selected to evaluate the smartphone-based CRS app. Open-ended questions were included to provide contextual perspectives on these criteria.

Results: *T*-tests demonstrated an improvement in student ratings of agreement with the evaluative criteria for this CRS smartphone app when comparing pre- and post-implementation survey data. This includes agreement with the CRS's functionality ($p = .001$), support ($p = .004$) and effectiveness ($p = .189$) at $\alpha = 0.05$, as well as overall usability across criteria domains ($p = .000$ at $\alpha = 0.05$). Respondents additionally suggested that specific features be changed or added to the current design to make it easier to navigate.

Conclusions: For educational apps to achieve optimal use and effectiveness, iterative design assessments should continue until the end-users truly benefit from the technology enhanced learning tool. This smartphone-downloadable CRS app proved to be a useful adjunctive tool for enhancing student learning in an online class. Yet there were numerous design recommendations provided by students that could further improve its usability.

Key Words: Classroom response system, Online education, Usability, Technology enhanced learning, Smartphone learning device

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1. INTRODUCTION

This usability study was conducted to determine whether a technology enhanced learning tool, specifically a classroom response system (CRS) that can be downloaded to one's smartphone, would be suitable for adoption in online classes in one particular suburban university in New York. Effective use of a CRS is potentially beneficial in higher education due to technological features that allow professors to pose questions for students to answer through a device with immediate computer-assisted aggregation of answers. This may allow for complementary interactions between professor and students even when such interaction is inhibited by large classes, student reluctance, or social discomfort.

Like many educational institutions, this university is increasingly offering distance education courses and programs. Little is currently known about the effectiveness of CRS integration into online courses. The purpose of this usability study was to determine whether the CRS' features will be easy for students to use as a technology enhanced learning tool in an online environment. While this particular CRS also has the capability to be a learning management system, this university has been using a different system for over a decade and has no immediate plan to replace it. Thus, the intent was to evaluate this smartphone application as a standalone CRS. This CRS was one of several apps that were tested by this university. The company allowed our use and testing of their app and our reliance upon their support staff to conduct this assessment in order to make an informed decision relative to adoption. The brand name is not mentioned in this manuscript.

Conducting a usability study is relevant prior to investment in the acquisition and adoption of any type of technology. Ghalibaf et al. described usability testing as a type of evaluation approach that focuses on human-computer interactions.[1] Its goal is to examine whether specific features and functions meet the needs of intended users. Computer technologies must be consumer-centric with features that are easy to learn and use, and supportive of efficient work.[2] The usability testing of this CRS focused on features that facilitate technology enhanced learning, including usability measures of the CRS' functionality, support, and effectiveness when used in an online class.

1.1 Background

CRSs have been called various names, including but not limited to, clickers,[3] audience response systems,[4] and student response systems.[5] Early prototypes were hand-held devices, similar to television remote controls, that students bought and carried to class or which were loaned out to students at each class session. At any time during a particular class, the professor projected on the overhead screen several test questions (with discrete answer options) pertaining to the lesson. Students used the CRS to press a number corresponding to what they believed the correct answer to be. Students remained anonymous and their responses were instantaneously projected on the overhead screen in aggregated format for students and professor to review (typically in less than 5 seconds). The answer tallies provided the professor and students with instant feedback as to whether or not students understood the topic that was just discussed. The professor then clarified ambiguous topics or reinforced those that were not clearly understood by the students. Other important features of CRSs include preventing unnecessary embarrassment if students do not comprehend the discussion, allowing for timely and targeted reinforcement of subject matter, and improving the degree of comprehension of the topics covered in class.[6] The use of CRS as a technology enhanced learning tool makes learning more fun, engaging, and interesting among most students regardless of age, but more so for millennial students and those who are tech-savvy.[7]

There is now a large market for distance education. As stated by Magda & Aslanian, "nearly 60% of online college students who had a choice between online and on-ground actively chose online learning".[8] The same authors also stated that distance education offers more benefits such as: A) increasing students' ability to complete degrees faster or at their own pace because more courses are offered on a rolling year-round basis; B) substantial transfer of credits from school to school (for some institutions); C) less challenges for students in prioritizing from among many personal and professional responsibilities because of the convenience of not physically coming to school; and, D) supporting innovations that decrease costs.[8] In a recent large survey of 1,500 online students (past, current, and prospective), only 12% said they used their mobile devices in course-related activities while 70% said they wished that they had maximized their use of their mobile devices in their course work.[9] The CRS that was the subject of this current usability study is a web-based application that can be accessed on any mobile device.

It is important to note that the proportion of Americans who own smartphones has increased significantly to 77% in 2018, as compared to 35% in 2011.[10] Magda & Aslanian suggested that every online college student owns a smartphone or tablet, and so mobile-friendly content is essential.[8] Those authors further asserted that 85% of students who have experienced both in-person and virtual classrooms felt that learning online was the same or better than attending courses on campus, and yet 57% reported that interactions with classmates were very important to their academic success.[8] Even

assuming that access to such technology among college students is assured and that CRS software can be adopted, the acceptability of CRS features and functions is unclear and likely unique to each different CRS. The CRS that was the focus of this usability study is one of the first that could be downloaded for free onto one's mobile device, a departure from the hardware device designs of the 1990s.[11]

1.2 Significance of the study

Educators constantly look for strategies to enhance learning, knowledge retention, and student engagement.[3,5,12,13] Such strategies may help to overcome serious educational challenges including large classes, short attention spans among students, student isolation in distance learning programs, and other causes of distraction and competing priorities. The use of technology enhanced learning tools, specifically the use of CRS, is one such strategy.

Recent research studies have demonstrated significant benefits in terms of improved student engagement, knowledge retention and recall, and supportive student-centric learning.[5,7,13,14] Technological devices have been recommended as useful, accessible, and portable tools to enhance active and shared learning, peer collaboration and group interaction, and student productivity.[15] While the use of clickers in classrooms has demonstrated mixed impacts on immediate student learning and long-term retention,[5,13] most students involved in such studies considered learning sessions that used clickers to be engaging, memorable, and helpful.[16] These previous studies were conducted in face-to-face classroom settings. Smartphone-accessible CRSs are fairly new and their applicability and usefulness in online education need to be scrutinized and examined. With the increasing trend of offering distance learning courses in online environments, it can be helpful to adopt a CRS that is intuitive, effective, useful and easily downloaded to mobile devices.

1.3 Usability testing & measurement

Usability testing is that aspect of the technology lifecycle where developers and designers evaluate the product in its varying stages of completion with the goal of determining whether the product meets its users' needs, is easy to learn and use, enhances efficiencies and workflow processes of users, and increases user satisfaction.[17] Usability studies involve various key stakeholders from end-users to developers, designers, and heuristics experts. Lopes et al. demonstrated the importance of a user-centered design in promoting user satisfaction and successful adoption, incorporating users in the planning, testing, implementation and evaluation phases of development.[2]

A technological application used in education must include a well–designed interaction concept, pedagogical effectiveness, relevant learning content, and supports and features that will be appropriate to the needs of the users.[18] Evaluation criteria, depending on the interests of developers, designers, end-users and managers, may include content, support, visual design, navigation, accessibility, interactivity, and user self-assessment, learnability, and motivation to learn. For this particular CRS usability study, three evaluation criteria were selected including functionality, support, and effectiveness, recognizing that several other evaluative foci are subsumed within these three elements.

Functionality is an aspect of user-centered design. This refers to the features that should be included in the program or application design for it to meet the needs of users. Having features that are relevant, useful, and appropriate, and which will enhance the work of the users, will facilitate adoption, user satisfaction, and improved user productivity and efficiency.[19] The functionality measure included in this usability study assessed ease of application download, navigation, learnability, intuitiveness, as well as the degree to which the CRS offers sufficient structures that users need to enhance their learning.

Support is "the aspect related to features that have a direct connection to the delivery of learning materials and academic discussions. . . ".[18] Lopes et al. stressed in their research that user-centric and supportive systems correlate to user satisfaction.[2] This can be achieved when the design and implementation phases of the software application include input from users, and when features of the product are those that are relevant and appropriate to their needs. The support measure in this usability study assessed the product's user-friendliness, its ability to support users' learning needs, and user satisfaction.

Effectiveness, according to Revell and McCurry, "promotes active learning, increases participation, and provides students and faculty with immediate feedback that reflects comprehension of content and increases faculty-student interaction".[20] The effectiveness measure in this study assessed the application's accessibility when needed, adaptability, ability to provide immediate feedback, remediation, or reinforcement of class topics to students by professors, and ability to serve as an add-on tool to maximize student learning.

2. METHODS

This usability study utilized a mixed method, one group, pretest/posttest descriptive design. Convenience sampling was used to engage students (n = 48) enrolled in an online course during their first semester of a master's degree nurse practitioner program at a large suburban university located

in New York State. Institutional review board approval was obtained prior to the commencement of the research. A five-point Likert scale instrument was designed to collect data from students. The instrument was comprised of 21 statements that respondents rated in terms of their degree of agreement (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree). These statements included descriptors of the three usability domains (functionality, support, and effectiveness) selected to evaluate the smartphone-based CRS software application. Each of these evaluative domains was measured through seven descriptive statements. All statements were shuffled and purposefully presented in randomized order. Open-ended questions were also included to provide contextual perspectives on these criteria.

A graduate assistant gathered data in order to reduce potential bias related to coercion or familiarity since one of the researchers also served as the professor who taught the class from which respondents were recruited. The graduate assistant was provided a script to use as a guide when giving survey instructions to students. The survey was administered twice during a 15-week semester, first at the beginning of the semester before the CRS was introduced and again two weeks prior to the end of the semester. In between the administration of the two surveys, the CRS was used by the professor to gain feedback from the students.

In this online course, students were often given multiple choice or open-ended questions during the class sessions to ascertain their comprehension of the topics covered. Students accessed these questions through their CRS application on their smartphones. The professor or the application support staff keyed in the questions to the web-based CRS. Course topics were grouped into three-week time periods and students engaged relevant subject matter and answered corresponding CRS questions during these three-week blocks. Students were given a deadline to answer the CRS questions, at which time the professor or the application support team downloaded the responses in aggregated format and the professor presented findings back to the students through the university's learning management system. Based on the accuracy of student responses, the professor provided feedback, clarifications, or reinforcements to complement the learning process.

3. RESULTS

Most student respondents were young adults, with 71% under the age of 35. About one-third of respondents returned to school for graduate studies within a year of obtaining their undergraduate degrees, while 25% came back for higher education in 2-3 years and another 21% returned within 4-7 years.

3.1 Skill and comfort with the use of technology

Nearly all respondents (96%) rated their comfort and skill with technology as average or above average. Specifically, one-third (33%) reported having average comfort and skill with technology, half (50%) reported well-established comfort and skill, and another one-eighth (12.5%) identified extreme comfort and skill using technology. All (100%) of the respondents owned a smartphone. Two-thirds (67%) of the respondents had prior experiences in online classes. However, given a choice, about two-thirds (65%) of respondents would choose a traditional face-to-face class rather than one offered online. The vast majority of respondents (92%) had not used this particular CRS in prior classes. This can be explained by the fact that this CRS was fairly new in the market. About one-third (36%) of the students in this study had used other brands of CRS prior to enrolling in the Master's program (see Table 1).

3.2 CRS functionality

The proportion of respondents who agreed or strongly agreed with pre-implementation survey statements pertaining to the ease of uploading a CRS app increased from 79% to 95% during the follow-up survey. Agreement with statements pertaining to ease of understanding upload instructions increased from 80% to 95%. Concurrence with ease of learning to use a CRS increased from 73% to 100%. Respondent agreement with statements about ease of navigating CRS screens increased from 63% to 80%. The assent with a lack of barriers to using a CRS increased from 67% to 83%, yet concurrence with the intuitiveness of a CRS only increased from 59% to 64%. Importantly, 64% of respondents agreed or strongly agreed that this CRS has the features that respondents will need in their academic program and this number actually decreased slightly to 63% over the course of the semester. It is evident from these data that most students strongly agreed or agreed with most of the functionality measures of this CRS, and the level of assent generally increased between pre- and post-implementation of the technology enhanced learning device (see Table 2).

3.3 CRS support

Respondent agreement with statements relevant to CRS support also increased during the study period. Concurrence about CRS features being helpful to student studies increased from 51% to 59%. The proportion of respondents who agreed that this CRS is a helpful resource increased dramatically from 47% to 72%. Agreement that this CRS supports students' educational needs increased from 46% to 58%. Prior to implementation, 53% of student respondents agreed that

using the CRS made them happy, and this proportion increased to 64% towards the end of the semester. Yet, the proportion of respondents who felt that the CRS satisfactorily assisted the learning process decreased from 59% to 50% (despite a minor increase in the weighted mean of responses). When it comes to statements affirming that a technology enhanced learning tool is user-friendly, the degree of assent increased from 72% to 87%. Sixty percent of the students initially agreed that the CRS served the purpose for which it was designed, and this proportion increased to 72% by the end of the semester (see Table 3).

3.4 CRS effectiveness

Participant agreement with ease of access to a CRS increased from 68% to 89% during the study period. The proportion of students who agreed that they would easily adapt to using a CRS app increased from 83% to 97%. Prior to the study, 66% of respondents agreed that the CRS is an add-on tool to support learning, and this rate just barely increased to 67% by the end of the semester. Three-fifths of respondents (60%) initially agreed that a technology enhanced learning device is an efficient tool in providing student feedback, and this rate increased slightly to 64% by the end of the study period. Agreement that a CRS is an efficient tool for learning decreased from 60% to 58% (despite a minor increase in the weighted mean of responses) (see Table 4).

More significant decreases in agreement were observed for two effectiveness measures. Agreement that students would be able to maximize their use of a CRS during the course of their studies fell from 70% to 53%, and 76% of students initially agreed that a CRS would provide them feedback if lessons were clearly understood and learned, while only 68% agreed with this criterion by the end of the semester.

3.5 *T*-tests of significance, pretest posttest, repeated measures

When the pre- and post-implementation usability study results were subjected to *t*-tests of significance, increases in all three usability measures–functionality ($p = .001$), support ($p = .004$) and effectiveness ($p = .189$)–individually proved to be statistically significant at $\alpha = 0.05$. Collectively, increases across all three usability measures likewise showed statistical significance ($p = .000$ at $\alpha = 0.05$) (see Table 5).

3.6 Qualitative findings

The answers to open-ended questions at the end of the survey provide further insights into research questions of this usability study. Three questions prompted respondents to reflect on their expectations of the CRS, features that they think should be added, and those that they did not like.

Table 1. Frequency distribution of respondents' profile (n = 48)

	n	%
Q1-Where do you fall under the following age range?		
20-25	11	22.90
26-30	10	20.80
31-35	13	27.10
36-40	3	6.30
41-45	4	8.30
46-50	6	12.50
51 & >	1	2.10
Q2-How many years have you been a nurse before enrolling in the Master's program?		
1 year or less	17	35.40
2-3 years	12	25.00
4-7 years	10	20.80
8-12 years	7	14.60
13-17 years	0	0.00
18-22 years	2	4.20
23 years & >	0	0.00
Q3-What is your skill and comfort level with using technology?		
Extremely comfortable and skillful	6	12.50
Comfortable and skillful	24	50.00
Average	16	33.30
Uncomfortable and unskillful	2	4.20
Extremely uncomfortable and unskillful	0	0.00
Q4-Do you own a smartphone?		
Yes	48	100.00
No	0	0.00
Q5-Have you attended an online class before this course?		
Yes	32	66.70
No	16	33.30
Q6-Would you rather attend a face-to-face class?		
Yes	31	64.60
No	17	35.40
Q7-Have you used this classroom response system before?		
Yes	4	8.30
No	44	91.70
Q8-Have you used another brand of this technology before?		
Yes	17	35.40
No	31	64.60

3.6.1 *Themes relating to respondents' expectations about the CRS*

1) Unclear expectations

At pre-implementation, some respondents did not understand the CRS or its use in their program of study. Others lacked understanding of this technology enhanced learning tool. Some other respondents said that they did not know what to expect since they had no idea what it would do. Two statements clearly reflect this lack of understanding: "not sure how this play into grading"; and, "I imagine it will be like [the name of the online learning management platform used at this uni-

versity].” Other students seemed vaguely optimistic, with comments such as: “hopefully, it will be helpful”; and, “I was told that it would be a great learning tool, helping me to have a firmer grasp on the materials taught in class.” At follow-up, responses indicated that some students still did not have a clear understanding of the purpose and use of the CRS. Examples of feedback at post-implementation include: “I need more time”; “I wish I had used it a lot more”; “I feel that I would need more exposure to give an educated opinion”; and, “it is primarily a feedback application for the professor”.

Table 2. Percentage frequency distribution and means for functionality usability of the CRS

	SA (5.0)**	A (4.0)	N (3.0)	D (2.0)	SD (1.0)	Total	Weighted Mean
1. It is easy to upload to the smartphone.							
PRE-TEST:*	30.40%	47.80%	21.70%	0.00%	0.00%	100%	4.09
POST-TEST:	63.20%	31.60%	5.30%	0.00%	0.00%	100%	4.70
2. Upload instructions are simple and easy to understand.							
PRE-TEST:	30.40%	45.70%	21.70%	2.20%	0.00%	100%	4.04
POST-TEST:	51.40%	43.20%	5.40%	0.00%	0.00%	100%	4.46
3. It is easy to navigate from screen to screen.							
PRE-TEST:	19.60%	43.50%	34.80%	2.20%	0.00%	100%	3.80
POST-TEST:	48.60%	32.40%	16.20%	0.00%	2.70%	100%	4.24
4. It is easy to learn.							
PRE-TEST:	21.70%	52.20%	23.90%	2.20%	0.00%	100%	3.93
POST-TEST:	40.50%	59.50%	0.00%	0.00%	0.00%	100%	4.41
5. Using it presented no barriers or issues.							
PRE-TEST:	8.70%	58.70%	26.10%	6.50%	0.00%	100%	3.70
POST-TEST:	34.30%	48.60%	14.30%	2.90%	0.00%	100%	4.14
6. It is intuitive.							
PRE-TEST:	8.70%	50.00%	37.00%	4.30%	0.00%	100%	3.63
POST-TEST:	19.40%	44.40%	36.10%	0.00%	0.00%	100%	3.83
7. It has most of the basic features helpful in my degree program.							
PRE-TEST:	8.50%	55.30%	31.90%	2.10%	2.10%	100%	3.66
POST-TEST:	17.10%	45.70%	34.30%	2.90%	0.00%	100%	3.77

*(Pre-test n = 46; Post-test n = 37); **(SA-Strongly Agree; A-Agree; N-Neutral; D-Disagree; SD-Strongly Disagree).

2) Clear expectations

Other students shared that they had firm opinions as to what this CRS is all about – that it is a learning tool to supplement the feedback mechanism between students and faculty. Responses indicated that lessons which students perceived to be unclear were given another round of explanations to enhance comprehension. Additionally, faculty and students could exchange feedback through the CRS so both could assess if a particular topic was understood. Some examples of students' responses include: “provide additional means of feedback in online courses where professors are not readily available”; “help me to have a firmer grasp of the materials taught in class and to know if I am absorbing the information”; “assist me with advancing my education”; “facilitate learning and provide easy access to feedback and resources”; and “I used clickers before, but this is more accessible. I do not need to remember to bring another tool to class”.

Some of these students maintained similar expectations about the CRS throughout the study period as evidenced by the following post-implementation responses: “easily accessible”; “increased participation in class”; “easy way to summarize the lessons learned during the block of weeks”; “identified what needed to be reviewed in depth”; “gave me insight on my level of understanding of the coursework”; “good tool to review a course”; and, “no complaints. It is a platform that did the job it was meant to do”.

3.6.2 *Themes relating to CRS features that should have been added*

1) Functionality issues

Respondents volunteered many constructive criticisms about the CRS. Navigation was a problematic issue. For example, only one question at a time appears per page and the CRS does not have the capability to automatically move to the next screen. Users of the app cannot “swipe left” to move to the next screen. Some felt there should also be the capability to go back to unanswered questions without having to keep

clicking the "back button". Others griped that the CRS offers little opportunity for interaction with peers. Some users suggested alert notifications be available when new questions have been added to the course so they can answer them promptly. Fingerprint functionality was also recommended where their thumbmark can be used to sign on to the CRS. Some students identified new features as suggestions for add-ons to the app, for example: "should be able to integrate access to books and articles"; "tools should be available to help with improving our writing"; and, "live chat should be available". The findings captured in these comments were all communicated to the CRS liaison to the university for consideration in upcoming upgrades.

Table 3. Percentage frequency distribution and means for support usability of the CRS

	SA (5.0)**	A (4.0)	N (3.0)	D (2.0)	SD (1.0)	Total	Weighted Mean
1. Many of its features are helpful in my studies.							
PRE-TEST:*	8.50%	42.60%	42.60%	6.40%	0.00%	100%	3.53
POST-TEST:	18.90%	40.50%	37.80%	2.70%	0.00%	100%	3.76
2. It is an extremely helpful resource to me during the course of my studies.							
PRE-TEST:	10.60%	36.20%	46.80%	6.40%	0.00%	100%	3.51
POST-TEST:	40.40%	31.90%	25.50%	2.10%	0.00%	100%	4.11
3. It supports my educational needs.							
PRE-TEST:	13.00%	32.60%	45.70%	6.50%	2.20%	100%	3.48
POST-TEST:	21.10%	36.80%	36.80%	5.30%	0.00%	100%	3.74
4. I am happy using this CRS.							
PRE-TEST:	12.80%	40.40%	42.60%	0.00%	4.30%	100%	3.57
POST-TEST:	19.40%	44.40%	36.10%	0.00%	0.00%	100%	3.83
5. It is user-friendly.							
PRE-TEST:	17.00%	55.30%	27.70%	0.00%	0.00%	100%	3.89
POST-TEST:	44.70%	42.10%	10.50%	2.60%	0.00%	100%	4.29
6. It provides satisfaction because it helps with my learning.							
PRE-TEST:	6.50%	52.20%	37.00%	2.20%	2.20%	100%	3.59
POST-TEST:	16.70%	33.30%	44.40%	5.60%	0.00%	100%	3.61
7. It achieves the purposes for which it was designed for.							
PRE-TEST:	11.10%	48.90%	35.60%	2.20%	2.20%	100%	3.64
POST-TEST:	22.90%	48.60%	28.60%	0.00%	0.00%	100%	3.94

*(Pre-test n = 46; Post-test n = 37); **(SA-Strongly Agree; A-Agree; N-Neutral; D-Disagree; SD-Strongly Disagree).

2) Nothing more

Of note, some respondents were seemingly content with the existing features of the CRS. This is evident in the following responses: "nothing more to add"; and, "nothing needs to be added, seems sufficient". Additionally, some responded with "NA" (not applicable), "none", or "nothing" with regard to recommendations for additional features.

3.6.3 *Themes relating to CRS features that respondents did not particularly like*

1) Functionality problems

Respondents identified many features that were viewed as inadequate or problematic. These are illustrated by the following answers: "an improved touch response"; "difficult to keep track of what you did and didn't do"; "help isn't easily accessible"; "need to sign in to my course every time I use the app"; "cannot see my responses once I have submitted them"; "no autocorrect for spelling"; "no refresh button"; "immediate feedback is not possible"; "should use more graphics and icons in its app design"; and, "unable to see unanswered questions without having to go back and look".

Some respondents did not like how the CRS forces them to navigate from one question to the next. Said in different ways, these students described frustration with having to click on the "X" at the top left corner of the screen to exit out of the current question in order to get to the next. Some suggested that a "swipe left" would have been easier to move from question to question. Some students recommended that subsequent feedback items should automatically pop up when one completes answering a question.

2) Too soon to provide other suggestions

Some respondents would not provide highly specific or substantive suggestions. Examples of responses related to this

theme include: "the app is new to me. I need more time using this before I can make any recommendations"; "I did not have enough practice using this app"; "I am not sure. . . need to play around with it some more"; and, "have not used this long enough to determine how good the features are". Others said "none", not applicable", and "nothing" in terms of the features of the CRS that they did not like.

Table 4. Percentage frequency distribution and means for effectiveness usability of the CRS

	SA (5.0)**	A (4.0)	N (3.0)	D (2.0)	SD (1.0)	Total	Weighted Mean
1. It is easily accessible when I need to use it in class.							
PRE-TEST:*	14.90%	53.20%	25.50%	6.40%	0.00%	100%	3.77
POST-TEST:	40.50%	48.60%	10.80%	0.00%	0.00%	100%	4.30
2. It provides feedback if students understood the lessons or not.							
PRE-TEST:	30.40%	45.70%	21.70%	2.20%	0.00%	100%	4.04
POST-TEST:	27.00%	40.50%	24.30%	8.10%	0.00%	100%	3.86
3. One can easily adapt to using it.							
PRE-TEST:	14.90%	68.10%	14.90%	2.10%	0.00%	100%	3.96
POST-TEST:	45.90%	51.40%	2.70%	0.00%	0.00%	100%	4.43
4. I am able to maximize its use during the class.							
PRE-TEST:	19.60%	50.00%	28.30%	2.20%	0.00%	100%	3.87
POST-TEST:	26.30%	26.30%	39.50%	7.90%	0.00%	100%	3.71
5. It an add-on tool to facilitate my education.							
PRE-TEST:	8.50%	57.40%	27.70%	6.40%	0.00%	100%	3.68
POST-TEST:	19.40%	47.20%	33.30%	0.00%	0.00%	100%	3.86
6. It is an efficient tool to help me understand lessons taught in my classes.							
PRE-TEST:	10.60%	48.90%	34.00%	6.40%	0.00%	100%	3.64
POST-TEST:	21.10%	36.80%	34.20%	7.90%	0.00%	100%	3.71
7. It is an efficient tool that provides the feedback I need in my classes.							
PRE-TEST:	8.50%	51.10%	36.20%	4.30%	0.00%	100%	3.64
POST-TEST:	19.40%	44.40%	33.30%	2.80%	0.00%	100%	3.81

*(Pre-test n = 46; Post-test n = 37); **(SA-Strongly Agree; A-Agree; N-Neutral; D-Disagree; SD-Strongly Disagree).

Table 5. *t*-Test of significance of three usability measures (Pre-test, Post-test)

Usability Measures	*p*-value	Decision
Functionality α at 0.05 = 2.365	.000995*	Reject Ho
Support α at 0.05 = 2.365	.004244*	Reject Ho
Effectiveness α at 0.05 = 2.365	.188544*	Reject Ho
Overall Usability α at 0.05 = 2.080	.000*	Reject Ho

*Significant at α = 0.05; two-tailed test

4. DISCUSSION

The 100% rate of smartphone ownership exceeds the estimated national rate of 77%.[10] Together with the considerable comfort with technology among student respondents, these findings suggest that smartphone ownership is prevalent enough to be fully integrated into education to enhance student learning so long as there are sufficient opportunities and activities to capitalize on their availability and capabilities. While respondents rated the CRS positively in terms of most functionalities, there are some features that merit reconsideration. Students rated most of the functionality measures of this CRS between strongly agree and agree, and these ratings significantly increased between pre- and post-implementation of the technology enhanced learning device (p = .0001). However, respondents' comments in the open-ended questions of the survey contradicted this statistical outcome.

The discrepancy between the quantitative outcomes and the contextual responses of respondents might be due to any number of factors, including the short study time frame. For example, students might have rated the CRS highly during the follow-up survey, hoping their positive ratings would increase the likelihood of their suggestions being integrated into the app. If this were the case, the CRS functionalities would still be a good adjunctive learning tool for students if improvements could be made. The faculty researchers, CRS liaison and staff support, and the faculty development director concurred about this goal. The fix simply could not

be completed during the period of the usability study.

All the criteria for the support measure of this CRS' usability demonstrated an improvement in student ratings when comparing pre- and post-implementation survey data. Even with the slight decrease for the item relating to the CRS providing satisfaction to the students, the weighted mean from the follow-up survey increased to a small degree. When comparing the combined percentages of respondents who strongly agreed and agreed in both pre- and post-implementation, four out of seven criteria showed consistency or improvement in ratings: user-friendly features; capability to achieve its design purpose; ability to bring happiness to users; and, having many helpful characteristics.

Comments made by student-respondents confirmed that the CRS supported their learning process by serving as a supplemental tool for feedback between faculty and students, providing the opportunity for clarification of topics not readily understood, and strengthening knowledge with additional explanations when topics were not seemingly understood. Faculty researchers involved in this study echo these findings from the student surveys. They believe that the CRS satisfactorily supports learning to a limited degree. Faculty researchers would have been more satisfied with the support factor of this CRS if only the app had the functionality to readily upload feedback questions and collate responses for timely sharing and remediation, if necessary.

While four effectiveness criteria showed improvements in ratings of agreement between pre- and post-implementation data, the criteria referring to the CRS as an effective tool for learning showed a decrease in ratings at follow-up. However, there were more respondents who rated this criterion at the strongly agree level and the weighted mean yielded a slight increase from 3.64 to 3.71. The remaining two criteria: (1) one referring to this CRS as a feedback tool to help students determine if they understood the lessons discussed, and (2) their belief that they would be able to maximize the use of this CRS, showed a decrease in ratings by the respondents, resulting in a decrease in the weighted means.

The measure of effectiveness has to do with the CRS promoting active learning, increasing collaboration and class interaction, and providing instant feedback with lessons learned. While most of the effectiveness criteria were favorable, two were not rated generously. The CRS was deemed easily accessible to the students when they needed it (since all of them carried their smartphones at all times), served as a feedback tool, and was considered an added device to enhance and maximize learning. Again, this positive outcome is possible despite the professor's challenges with having to rely on support staff to upload questions and collate results, which delayed the feedback process to some extent. Benefits outweighed this limitation, and students seemed hopeful that their recommendations would have been integrated into the app design before their classes ended or before the post-implementation survey was conducted.

Student respondents identified many positive features of this CRS, including: easy to upload onto a smartphone; understandable instructions; intuitive app; quick to learn and use; and, serves as a good educational tool to enhance learning. All these features speak to a user-centered design, meaning it meets the needs of the end-users.[19] Thus, it seems that this CRS has many features that are helpful to the students' overall learning. The satisfaction level with the use of the CRS could have been greater if there were fewer flaws. It is, however, rare for any technological program to achieve perfect usability during its first run. This is one reason why usability studies are important and can take several iterations to achieve a highly usable and acceptable app.

There were many suggestions offered by student respondents to improve features they considered unfavorable. Students found navigating the system was not easy. Some students also said that it was too soon to judge the CRS. They preferred to have had more practice to really be able to provide meaningful suggestions. While some had nothing unfavorable to say about this CRS, a few mentioned they would have preferred other features to be added, which may be considered as signals of what these students considered lacking in the current system. This CRS needs modifications in order to maximize its use and optimize student learning, particularly if CRSs will become a mainstay in online education.

The researchers found the download instructions to very simple and the processes of learning, navigating and using the app to be intuitive. This CRS is potentially a helpful tool to facilitate students' learning processes when fully integrated and used in an online class. Despite these mostly positive evaluations of the CRS functionalities, the faculty researchers, however, found a critical issue with this CRS. It did not have a feature where professors could easily upload feedback questions into the app. Whether multiple choice or open-ended questions, professors have to enter the questions for each discussion block manually. The CRS liaison and support staff were helpful and keyed in the questions themselves once this limitation was identified.

Another challenge for the faculty researchers was the tedium of downloading and collating results of the student tests. Since this CRS is not integrated into the learning management system at the university, professors have to manually collate the results and upload findings to the learning management system. Again, once this was communicated to the

CRS liaison and support staff, they offered to do it for the faculty researchers. This was very helpful, but there were a couple of instances when there were considerable time lags because the professor was dependent on the support staff. Sending feedback to students was consequently delayed. Faculty researchers believe the CRS would be more useful and efficient if it were integrated into the learning management system. Having to key in the feedback questions, download and collate responses is cumbersome and adds tasks to heavy workloads. The timeliness of feedback to students is at the heart of any CRS.

Study limitations

It is clear that a one-semester usability study on an app that is not integrated into the learning management system is not sufficient in terms of time or infrastructure to make accurate judgments of this technology's true merits and shortcomings. It is also evident that having a control group would illuminate the differences between using a CRS in a face-to-face class and using it in an online course. A control group that does not use a CRS at all would also offer a good benchmark to understand any potential advantages of using a CRS in distance learning. The timeline and resources for testing this CRS in the online course did not permit such designs, but they are strongly recommended for similar studies in the future.

5. Conclusions & recommendations

This particular CRS, while not adopted by the university, presented many positive functionalities that can help students learn and maximize their education. The fact that students often find online classes isolating and the resulting learning to be uncertain suggests that automated feedback systems enhance students' online experiences. CRSs could increase student collaboration and interaction, transform them into active learners as they participate in the feedback process, and offer opportunities to improve their retention of content. These can be achieved through the use of clarifications and reinforcements offered as needed when feedback systems indicate the necessity to revisit certain topics. This study highlights the value of usability studies performed with end-users to gain their input in the design and evaluation of technology enhanced learning tools. After all, the student-users are the ultimate recipients of well-designed pedagogical tools.

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Conflicts of Interest Disclosure

The authors declare that there is no actual, potential or perceived conflict of interest.

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