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Original Article

An Evaluation of the Use of Student Response Systems in Teaching Diagnostic Reasoning for Physicians

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Background: Feedback is an aspect of teaching strategy that facilitates the learners to achieve expertise in the necessary skills for effective diagnostic reasoning. Several studies have demonstrated that student response systems (SRSs) are useful for enhancing learner engagement and obtaining immediate feedback. We aimed to examine the experiences of learners who used SRSs in a diagnostic reasoning class.
Methods: In 2016, an observational study was conducted on a 4-hour training course on "improving physicians' diagnostic process" that included 34 physicians. The Zuvio multimedia online interactive system was used. The learners could use smartphones to respond to the questions. A 5-point Likert-type scale quantitative questionnaire was designed to explore the viewpoints of the learners regarding the students' engagement, feedback, and outcomes. The learners were requested to complete a brief qualitative feedback form that included the following two sections: (1) the benefits and (2) the challenges of using SRSs. Qualitative and quantitative methods were used for data analyses.
Results: Total 32 participants (response rate: 94%) completed the questionnaire. Most respondents reported that using the SRSs enabled them to concentrate more effectively, express themselves in a stress-free environment, strengthen their interactions with peers and teachers, improve their participation in discussions, and obtain useful feedback. Three themes were identified from the qualitative results: (1) facilitating learning, (2) hardware limitations, and (3) question-development skills.
Conclusion: The SRSs can be easily implemented and positively affect the teaching of diagnostic reasoning. However, teachers should develop question-development skills so that the systems function more effectively in the instruction of diagnostic reasoning.

Key words: *student response systems, teaching strategy, feedback, diagnostic reasoning*

Introduction

Diagnostic reasoning is a basic skill for physicians. Physicians base their diagnoses on an intricate puzzle of clinical clues, and their diagnostic processes may entail pitfalls detrimental to patients.[1] Therefore, improving physicians' diagnostic reasoning is crucial to not only patient safety but also medical education.[2] Continuing education programs that focus on diagnostic reasoning in medical settings apply three major instructional strategies: feedback, deliberate practice, and metacognition.[3] Feedback-based instruction involves learners describing their diagnostic processes to the instructor and the instructor offering comments and suggestions; such interaction helps to elucidate the gap between the learners' competency and the objectives of the course and allows for the administra-

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tion of proper interventions to address their learning needs.[4] However, this instructional strategy is limited in two aspects: (1) the instructor in a feedback-based course attended by dozens of learners may not have adequate time to provide feedback to every individual attendee; (2) the attendees in these courses may engage insufficiently because of concerns about embarrassment when they express their views.[5] In brief, although this feedback-based instructional strategy has been acknowledged as an effective teaching strategy, satisfactory learning outcomes can be achieved only when learner engagement is maintained.[5]

A previous study suggested that student response systems (SRSs) facilitate in-class student engagement and feedback.[6] In Taiwan, most universities use a cloud-based SRSs named Zuvio.[7] It allows instructors to design questions in various formats (e.g., multiple-choice questions [MCQs], open-ended questions, and composite question sets) for in-class learning activities and project these questions onto a projection screen for students to anonymously respond through Internet-enabled smartphones or tablet computers. Immediately after it receives the students' responses, the SRSs presents results graphically for the instructor to evaluate students' strengths and weaknesses and provide feedback.

SRSs have been implemented in numerous higher education courses.[8] However, no study has discussed the strengths and weaknesses of adopting SRSs in continuing medical education on diagnostic reasoning.[9] Thus, this study used both qualitative and quantitative methods to explore the experiences of learners who used SRSs in a diagnostic reasoning class and discussed possible difficulties in implementing the systems in such courses.

Methods

Zuvio was adopted to enhance the engagement and feedback giving of attendees in a 4-hour diagnostic reasoning course that was held in March 2016 and included lectures combined with discussions in the following topics: dual-process theories, cognitive bias, problem representation, Bayes' theorem, debiasing strategies, and narrative reasoning. The goal of this course is to decrease the incidence of diagnostic error. Each lesson comprised several clinical vignettes for discussion and MCQs to facilitate understanding how the diagnostic reasoning skills taught in the course can be applied. Fig. 1 presents a clinical vignette followed by a set of questions designed using Zuvio. Fig. 2 shows the results of participants' responses to the case described in Fig. 1.

This observational study received approval from the institutional review board of the Cathay General Hospital to conduct a study involving human subjects. We used both qualitative and quantitative approach to examine the experiences of learners who used SRSs. Thirty-four physicians participated in the diagnostic reasoning course, with 32 completing the questionnaire administered in this study after the course ended. The response rate was 94%. The course was established by the emergency department, thus 84.4% of the respondents were emergency physicians and all of the lessons taught in the course were emergency medicine cases.

The questionnaire comprised two parts. The first part involved a quantitative 5-point Likert-type scale with 10 statements. Respondents were asked if they strongly disagree, disagree, are neutral, agree, or strongly agree in response to each statement. Percentage of who agree or strongly agree was calculated. The second part of the questionnaire, which consists of two semi-structured open-ended questions, provides an opportunity for the respondents to express their insights that cannot be offered by the quantitative measures. Respondents provided their opinions concerning the benefits and challenges of using SRSs.

This study investigated the experiences of SRSs implementation on attendees' engagement, feedback giving, and learning outcomes. Therefore, the questionnaire contained items on these three dimensions, and the content validity of the questionnaire was examined in terms of accuracy, relevancy, and scope by six emergency physicians who are conversant in diagnostic reasoning and one medical educator. Its content validity was assessed on a 4-point Likert-type scale (1 = "highly irrelevant" and must be removed; 2 = "irrelevant" and should be removed; 3 = "relevant" and can be used after revision; and 4 = "highly relevant" in terms of content and wording and can be used without revision). The questionnaire had a total content validity index of 0.98 (n = 6) and Cronbach's α of 0.93 (n = 32),[10] indicating satisfactory reliability and validity.

Students' opinions concerning the SRSs recorded using the questionnaire were qualitatively analyzed using the constant comparative method that was based on grounded theory.[11] The qualitative data were coded independently by two researchers in this study. Where

Patient A is a salesperson, and Patient B is a teacher. The diagnoses of their medical conditions were delayed. Physicians share the same view regarding this. Which of the following views do you think they share?

1. Aha! I figured out your problem. (premature closure)
2. Here we go again. I'll take care of this the same way. (anchoring effect)
3. It turned out just as I'd thought. (confirmation bias)
4. I can't give it any serious thought. (vertical line failure)

Fig. 1. Clinical vignette followed by a set of questions designed using Zuvio.

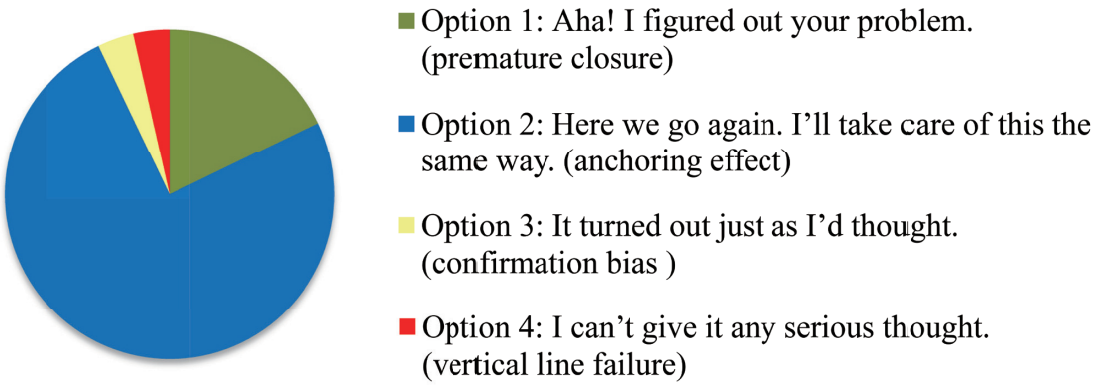

Fig. 2. Results of participants' responses to the case described in Fig. 1.

disagreement occurred during coding, discussions were held to derive a consensus. Coding rules were recorded in an audit trail as reference material for the independent coding processes. Once all relevant codes were identified, they were grouped together into meaningful categories and domains.

Results

Among the 32 attendees who completed the questionnaire, 4 (12.5%) reported having used Zuvio, whereas the remaining attendees (87.5%) used it for the first time. Table 1 tabulates the results of their responses to the 10 statements listed on the quantitative scale. Most respondents shared the view that using the SRSs enabled them to more effectively concentrate during the course, express their views in a stress-free environment, strengthen their interaction with peers and teachers, improve their participation in discussions, obtain more useful feedback, and achieve more favorable learning outcomes. Three themes were identified from the qualitative results: (1) facilitating the learning, (2) hardware limitations, and (3) question-development skills.

Facilitating the Learning

The SRSs ensured the anonymity of individual respondents, enabling them to offer their opinions in a stress-free environment. Additionally, the system presented response results in real time whereby the attendees compared their responses with each other. The instructor summarized the results, provided feedback, and instructed the learners to analyze clinical cases from different perspectives. One attendee stated, "It enabled me to express my views and obtain feedback in a stress-free environment." Another reported, "It presented the attendees' views in real time, allowing the instructor to identify their needs and adjust the course content accordingly."

Hardware Limitations

Operated through cloud computing, Zuvio is accessed in this study only through a Wi-Fi connection. However, some attendees failed to access the SRSs because of the spatial constraints of the venue in which the diagnostic reasoning course was held. Moreover, the size of statistical charts projected onto the screen could not be adjusted; one attendee sitting in a back row remarked not being able to see the words on the screen clearly.

Table 1. Responses toward the impact of using SRSs in a teaching diagnostic reasoning class

Description	Percentage of who agree or strongly agree
More focused in class	81.3%
More engaged in class	87.5%
Participated more with peers in class	96.9%
Participated anonymously	100.0%
Interacted more with peers to discuss ideas	81.3%
Actively discussed misconceptions	87.5%
Instructions that could be modified based on feedback from students	84.4%
Increase in learning performance	90.6%
More favorable learning outcome when learning with SRSs	90.6%
Provision of regular feedback	90.6%

SRSs: student response systems.

Question-Development Skills

Question development should consider the length of the question descriptions and the objectives of a course. In the course, complex clinical vignettes were presented in a series of slides and attendees were unable to recall the stories when the slide with the question statement appeared. Thus, some of the attendees recommended that the instructor return to the slide where the vignette begins or they would have forgotten the clinical context. Additionally, an attendee reported that the stems and options of MCQs affected responses. Specifically, some MCQs used in the course were not clearly described. Zuvio facilitates designing essay questions, although we did not use such format and one attendee was concerned that essay questions would be more difficult to administer because typing words would take considerable time.

Discussion

This study demonstrated that Zuvio delivered an interactive learning environment by sharing other learners' view with all attendees. This enabled the instructors to provide appropriate feedback according to learners' responses. This finding corresponded with that of a previous study.[8] In his seminal work on feedback in clinical medical education, published in 1983, Ende maintained that clinical medical educators should use feedback to facilitate their students' learning.[12] Since then, feedback provision has been extensively explored in the medical education community. Furthermore, models for enhancing the impact of instructor feedback on students' learning have been proposed, such as the Brown Educational Guide to the Analysis of Narrative (BEGAN), the Reflection Evaluation for Learners' Enhanced Competencies Tool (REFLECT), and the ECO models (emotion, content, outcome).[13] Nonetheless, few studies have discussed how technologies can be employed in a manner that enhances the benefits of feedback.

In their review of 650 studies on feedback in medical education, Bing-You et al. found that only 2.2% of the studies used SRSs among medical students.[13] Compared with previous studies, the present study recruited resident physicians and specialists from various fields of medicine. Thus, this study helped address the existing literature gap in the use of SRSs to enhance the impact of instructor feedback on medical practitioners' continuing education. In brief, the use of the systems to strengthen the educational benefits of feedback for medical students and practitioners has been empirically investigated.

The quality of MCQs designed affects attendees' responses in a SRSs-based course on diagnostic reasoning.[3,14] Length, question items, difficulty, and validity of clinical vignettes determine the quality of MCQs.[14] Therefore, although SRSs provide real-time results of student responses, allowing instructors to modify their instructional plans, the quality of questions is instrumental in the accomplishment of course objectives.[14] As the competency-based education approach is increasingly adopted, questions for SRSs-based medical education courses can be created in a manner that involves deconstructing the experts' reasoning process to develop a cognitive model which, in turn, is used to establish a clinical vignette.[15] This

cognitive approach to question development could evaluates higher-order skills.[15] Integrated into SRSs, which deliver immediate feedback, the approach may help further learning outcomes.

SRSs operates through cloud computing and therefore have software and hardware limitations. This study found that Zuvio could be accessed only through Internet-enabled mobile devices or Wi-Fi connections and the size of charts projected onto the screen could not be adjusted. Studies have also identified other limitations in the systems: (1) the equipment may cause distraction, (2) the equipment may causes instructors anxiety regarding technology failure, (3) most of people requires instructor time to learn how to use the technology, (4) it needs cost for learners and instructors, (5) less experienced instructors cannot adjust to student feedback, (6) discussion leads to wasting time, and (7) students find it difficult to shift to a new approach to learning.[10,11] Despite these limitations, SRSs are increasingly upgraded with their growing use and are likely to prevail in the classroom. This study demonstrated the use of an SRS to enhance interaction in a large-scale lecture. SRSs may also contribute to instruction in the following aspects: (1) pre-assessment and post-assessment for content comprehension, (2) combining theory and practice by using polling function in the SRSs, and (3) enabling peer evaluation in the system to encourage feedback exchange among learners.[7]

The limitations of this study and directions for future research are detailed as follows. First, this is a single, observational study with few learners. Therefore, the strengths and weaknesses of SRSs adoption in continuing education were not sufficiently elucidated. How this technology can most effectively be applied to diagnostic reasoning instruction requires further investigation. Second, this study investigated the functions of SRSs only from learners' perspective. These systems are operated by instructors, future studies can use qualitative or quantitative methods to explore instructors' opinions on how to efficiently use the systems. Findings from such investigations can be used to improve instructor training. Third, although most respondents in this study reported more favorable learning outcomes, this study did not establish whether their improvement in diagnostic reasoning is attributable to using Zuvio. Future studies can assign a control group and develop learning outcome indicators to determine the effectiveness of SRSs.

This study shows that the respondents who used Zuvio for learning reported having satisfying experience because it helped them to concentrate during the course, furthered their interaction with peers and instructors, received immediate feedback, and allowed them to submit responses anonymously. However, for SRSs to function more effectively in diagnostic reasoning instruction, instructors should learn to develop MCQs to more completely accomplish their instructional objectives and use cognitive models to develop reasoning-based clinical vignettes.

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