Original article

Applied Educational Research in Medical Practical Exercise Courses Using a Real-time Response System

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Abstract

In this study, it was found that in courses involving practical exercises for larger class sizes, the implementation of a real-time lesson response system can improve student lesson evaluations, teacher lesson delivery skills, and lesson format. In this context, teacher practical-lesson delivery skills refer to not only tool literacy for using the real-time lesson response system, but also the teacher's mode of engaging students with the lesson itself. In this study, the implementation of a real-time lesson response system not only resulted in the improvement of lesson evaluations and lesson content, but may also be considered to suggest possibilities for a new form of active learning in larger classes.

Introduction

1. Background

There are two main styles of communication, one-way and two-way. When looking at university-level lessons as a style of interpersonal communication, we note that while keeping an eye on student reactions and comprehension during a lesson might be possible in seminar-style classes involving limited numbers of students, classes with large numbers of students require some way of developing the lesson to engage students in some form of two-way communication. Methods of gauging student reaction in larger classes include measuring students' lesson comprehension and lesson evaluations, such as by providing students with short report assignments or administering lesson evaluation questionnaires. Nevertheless, we may ask how lessons could be transformed by introducing a system that allows students to respond to lessons in real time in large classroom settings. One such system, which may be considered a typical method for carrying out real-time lesson response, is the clicker (Figure 1).

Figure 1. A clicker

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The term "clicker" may refer to either the remote controlled device students use to provide responses during a lesson or the person who "clicks" the device, hence its name [1]. A large number of studies using clickers have been carried out to date, with reported implementations in the liberal arts [2], practical exercise courses [3], and medical subjects such as epidemiology [4], as well as their use in conjunction with learning management systems [5].

However, despite the widespread reporting of educational applications involving the implementation of clickers, there does not appear to be much in the way of detailed quantitative or qualitative analysis of their educational impact based on lesson evaluations by students or lesson reflection on the part of teachers. Especially in larger classrooms, where it is difficult to grasp student responses at the individual level, there appears to be demand for a detailed analysis of the kinds of evaluations made by students and teachers when developing lessons using real-time responses.

2. Challenges

This study analyzed a course entitled "Medical Fee Billing Theory," which involves calculating itemized breakdowns for determining the cost of medical care (i.e., medical fee points). The final goal of this course is to pass the Medical Clerk administered by the Japan Medical Education Foundation. The course consists of lectures in which students learn about medicine-related laws and regulations as well as rules pertaining to the calculation of medical fees and skill-testing; which include practical exercises that entail tests of practical skill in which students solve related sample questions and past problems and check over medical fee statements (i.e., receipts). Normally, the groundwork for examinations that assess these types of medical office skills is carried out largely in institutions such as colleges and vocational training schools, where students prepare in small classes of twenty or fewer

individuals. This is conceivable because the very nature of the course necessitates that teachers approach student questions on a one-to-one basis. For example, students must have the medical fee statements they prepare checked by the teacher, who must also point out errors that students may find difficult to discover on their own. Therefore, as far as the author is aware, one does not find educational institutions with class sizes of around 100 students that offer preparatory lectures for the Medical Clerk. However, even if a lecture on medical fee billing practices were offered to 100 students, it would still be necessary to correctly grasp students' comprehension and evaluation of the lessons. This is not merely a necessary challenge for increasing the pass rate for the qualification examination. More generally, the implementation of a real-time lesson response system in large classrooms has the potential to improve lessons in the future – such as possibilities for student comprehension and evaluation, teacher skill formation, and the development of new ways of delivering lessons – even in practical exercise-based courses where such activities would normally be difficult.

3. Purpose

To investigate changes in the educational practices of teachers and student lesson evaluations resulting from the use of a real-time lesson response system (clicker) in classes of sufficient size to make the measurement of individual responses of student members (in this case, approximately 90 students) difficult.

Method

1. Object

We investigated a "Medical Fee Billing Theory" course offered by a private university in Niigata Prefecture. The course involves calculating itemized breakdowns to determine medical fees, with the final goal of passing the Medical Clerk administered by the Japan Medical Education Foundation. The study cohort consisted

of 93 third-year students. The study was conducted over 3 days on the July 4, 11 and 18, 2014, for 3 hours each day (two 1.5 hour-long periods). These 3 days are placed as total summary in this course. Because there was not a difference in the contents too much about these lessons, the teacher judged that there was not an influence by the lesson contents. However, because this is a subject by the teacher, there is not necessity which is these 3 days. In the future, we must investigate the timing which uses Real-time Response System.

2. Student Lesson Evaluations

Students were asked to complete a lesson evaluation questionnaire at the end of class on each of the 3 days noted above. The items on the questionnaire were based on Taniguchi's questionnaire [6], and consisted of the following 20 items:

The items of this lesson evaluation questionnaire is five-point scale of "1. I don't think so at all.", "2. I don't think so.", "3. Neither.", "4. I think so.", "5. I think so strongly.", and the minimum value becomes 1 and the maximum becomes 5. Also, the result of the factor analysis and the covariance structure analysis which used this questionnaire is carried on the Japan Journal of Educational Technology [6]. According to this paper, as the questionnaire about the lesson evaluation, reliability and validity are supposed to be high.

(1) The topic dealt with in class was appropriate (topic).

(2) The structure of the class was coherent, well organized, and easy to follow (coherence).

(3) The distributed materials were pertinent (handouts).

(4) The lesson was presented at an appropriate level (level).

(5) The instructor was sufficiently prepared for the lesson (preparation).

(6) The instructor's language was clear and easy to hear (language).

(7) The instructor made appropriate use of the blackboard (blackboard).

(8) The instructor's style of explanation was easy to understand (explanation).

(9) I felt the instructor's passion for the material (passion).

(10) The lesson atmosphere stimulated student questions (stimulation).

(11) The number of students was appropriate (enrollment).

(12) The classroom was satisfactorily equipped (equipment).

(13) I took this course with a sense of active motivation (motivation).

(14) I have good attendance in this course (attendance).

(15) I engaged in this course enthusiastically (enthusiasm).

(16) I read ahead and do review work for this course (homework/review).

(17) The lesson content is interesting (interest)

(18) I am able to comprehend the lesson content (comprehension).

(19) I learned new information and skills (knowledge).

(20) Overall, I am able to give this course a high evaluation (evaluation).

3. Interactive Reflection by Instructors

Reflection exercises were conducted after class on July 4 and July 18, 2014. These involved two participants, an observer and the organizer of the course, and made use of the interactive reflection method [7].

Results and Discussion

1. Changes in Student Lesson Evaluation

(1) T-tests

To study how student lesson evaluations changed as a result of using the clicker, we compared the mean ratings for the twenty items making up the lesson evaluation questionnaire for the first and third implementations of the clicker using t-tests (Table 1). Significant differences at

Table 1. Mean scores, standard deviations, and t-values for items in the student lesson evaluation questionnaire

	Initial Implementation	Third Implementation	t-value
1. The topic dealt with in class was appropriate.	4.40 (0.66)	4.67 (0.54)	3.04**
2. The structure of the class was coherent, well organized, and easy to follow.	4.48 (0.53)	4.64 (0.63)	1.84†
3. The distributed materials were pertinent.	4.55 (0.57)	4.71 (0.53)	1.95†
4. The lesson was presented at an appropriate level.	4.48 (0.59)	4.66 (0.59)	2.01*
5. The instructor was sufficiently prepared for the lesson.	4.66 (0.52)	4.81 (0.47)	1.99*
6. The instructor's language was clear and easy to hear.	4.70 (0.46)	4.79 (0.49)	1.28
7. The instructor made appropriate use of the blackboard.	4.55 (0.64)	4.64 (0.67)	0.93
8. The instructor's style of explanation was easy to understand.	4.73 (0.45)	4.73 (0.54)	0.00
9. I felt the instructor's passion for the material.	4.83 (0.41)	4.86 (0.35)	0.60
10. The lesson atmosphere stimulated student questions.	4.31 (0.82)	4.67 (0.62)	3.26**
11. The number of students was appropriate.	4.49 (0.73)	4.71 (0.53)	2.27*
12. The classroom was satisfactorily equipped.	4.20 (0.89)	4.64 (0.61)	3.74**
13. I took this course with a sense of active motivation.	4.48 (0.67)	4.71 (0.55)	2.38*
14. I have good attendance in this course.	4.69 (0.54)	4.80 (0.46)	1.42
15. I engaged in this course enthusiastically.	4.39 (0.66)	4.79 (0.49)	4.50**
16. I read ahead and do review work for this course.	3.51 (1.05)	4.40 (0.77)	6.30**
17. The lesson content was interesting.	4.32 (0.73)	4.65 (0.63)	3.04**
18. I was able to comprehend the lesson content.	4.20 (0.72)	4.62 (0.62)	4.12**
19. I learned new information and skills.	4.36 (0.70)	4.78 (0.45)	4.55**
20. Overall, I am able to give this course a high evaluation.	4.70 (0.49)	4.82 (0.47)	1.66

**p < 0.01, *p < 0.05, †p < 0.10

the 1% level were observed for the eight items comprising "The topic dealt with in class was appropriate" (t = 3.04, p < 0.01), "The lesson atmosphere stimulated student questions" (t = 3.26, p<0.01), "The classroom was satisfactorily equipped" (t = 3.74, p < 0.01), "I engaged in this course enthusiastically" (t = 4.50, p<0.01), "I read ahead and do review work for this course" (t = 6.30, p<0.01), "The lesson content is interesting" (t = 3.04, p < 0.01), "I was able to comprehend the lesson content" (t = 4.12, p < 0.01), and "I learned new information and skills" (t = 4.55, p < 0.01). Significant differences at the 5% level were observed for the four items comprising "The lesson was presented at an appropriate level" (t = 2.01, p < 0.05), "The instructor was sufficiently prepared for the lesson" (t = 1.99, p < 0.05), "The number of students was appropriate" (t = 2.27, p < 0.05), and "I took this course with a sense of active motivation" (t = 2.38, p < 0.05).

Given that significant differences were observed for twelve of the twenty questionnaire items, use of the clicker had the effect of significantly increasing student lesson evaluations for the targeted course. In particular, in the

Table 2. Results of factor analysis of the first implementation

Factor	Item	Factor Loadings			
		I	II	III	IV
1	Handouts	.734	.369	.046	.114
	Knowledge	.701	.300	.348	-.010
	Comprehension	.686	-.067	.344	.156
	Coherence	.640	.442	.094	.225
	Level	.628	.287	-.008	.533
	Interest	.559	.185	.527	.024
	Topic	.508	.351	.328	.337
2	Explanation	.207	.742	.278	.331
	Preparation	.421	.706	.052	.143
	Blackboard	.355	.704	.161	.249
	Passion	-.013	.661	.370	.009
	Evaluation	.345	.610	.377	.037
	Language	.503	.506	.226	.033
3	Motivation	.266	.130	.799	.218
	Attendance	.149	.184	.686	-.167
	Enthusiasm	.257	.311	.676	.262
	Homework/review	.075	.126	.582	.096
4	Equipment	.025	.075	.038	.844
	Enrollment	.282	.159	.199	.594

Table 3. Results of factor analysis of the third implementation

Factor	Item	Factor Loadings			
		I	II	III	IV
1	Language	.871	.146	.212	.130
	Explanation	.792	.276	.250	.053
	Preparation	.781	.220	.185	.086
	Evaluation	.780	.216	.277	.161
	Passion	.732	.164	-.015	.292
	Level	.657	.563	.310	.119
	Coherence	.632	.528	.291	.118
	Stimulation	.506	.313	.439	.006
2	Interest	.299	.822	.169	.256
	Comprehension	.533	.694	.220	.112
	Knowledge	.431	.662	.095	.346
	Homework/review	.010	.650	.386	.316
	Handouts	.545	.608	.271	-.137
	Topic	.461	.578	.195	.164
3	Enrollment	.229	.190	.789	.104
	Equipment	.246	.163	.784	.150
	Blackboard	.365	.486	.539	.225
4	Attendance	.180	-.020	.102	.862
	Motivation	.113	.496	.046	.706
	Enthusiasm	.124	.429	.278	.743

context of a highly specialized subject matter such as Medical Fee Billing Theory, the finding that the mean ratings for the three items "I learned new information and skills", "I was able to comprehend the lesson content", and "The lesson content was interesting" underwent a significant increase after only the third lesson suggests that the clickers worked to promote comprehension and interest in this subject.

In addition, the fact that the implementation of the clicker in the lessons led to an increase in student evaluations that "The instructor was sufficiently prepared for the lesson" indicates an improvement in the evaluation of the teacher's lesson preparation, while the increase in the evaluation that "The classroom was satisfactorily equipped" also suggests that the system was being used effectively in the classroom setting.

(2) Factor Analysis

Next, in order to investigate changes in the latent variables in the student lesson evaluations, factor analysis of the 20-item questionnaire from the first and third clicker implementations was conducted. Table 2 presents the results of factor analysis (principal component analysis, varimax rotation) for the first clicker implementation, while Table 3 presents the results of factor analysis (principal component analysis, varimax rotation) for the third clicker implementation. Note that the

names of the items in Table 2 and Table 3 are abbreviations of the items listed in Table 1.

Focusing first on "evaluation" as an index of the overall evaluation of the lessons, examining the factor in which "evaluation" is included reveals that the common items between the first and third implementations are "preparation", "language", "explanation", and "passion." This suggests that, in the lessons being analyzed in this study, there exists a consistent association among these four items within the overall evaluation. Moreover, it was found that a total of four factors existed, the other factors being a factor consisting of "topic", "handouts", "interest", "comprehension", and "knowledge"; a factor consisting of "motivation", "attendance", and "enthusiasm", and a factor consisting of "enrollment" and "equipment." The fact that these results represent somewhat different factor analysis results from those obtained in a previous study using the same questionnaire [6] suggests the possibility that depending on lesson content, the factors that influence overall lesson evaluation may vary as a result of contingent circumstances such as the teacher in charge of the class, lesson format, and enrollment.

Specifically, the previous study that used the same questionnaire [6] included "evaluation" in factors associated with "student outcomes" like "interest", "comprehension", and "knowledge"; however, in this study it was included in factors associated with "teacher effort", such as "preparation", "language", "explanation", and "passion."

In addition, when we compare Table 2 and Table 3, we find a change in the items that comprise each factor. In the analysis of the results of the third clicker implementation, the items "coherence", "level", and "stimulation" have been added to the same factor as the item containing "evaluation", with the factor including "evaluation" becoming Factor 1. This seems to suggest that, as a result of using the clicker, considerations such as the fact that the level of

instruction became more appropriate and that the structure of the lesson became more coherent have become linked to the overall lesson evaluation.

(3) Multiple regression analysis

Finally, in order to investigate changes in items having an impact on overall lesson evaluation, multiple regression analysis was carried out, using the item "Overall, I am able to give this lesson a high evaluation" as a dependent variable, and the other 19 items as independent variables. Figure 2 shows the results of multiple regression analysis of the first clicker implementation, while Figure 3 shows the results for the third clicker
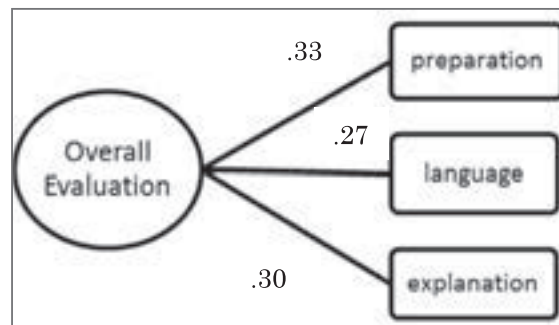

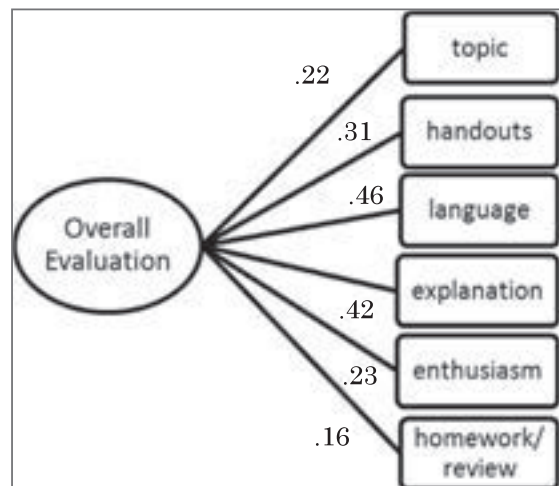Figure 2. Model showing the effect on overall evaluation in the first implementation

Figure 3. Model showing the effect on overall evaluation in the third implementation

implementation (note that for the sake of space, only the single independent variable yielding any significant difference is described here).

From these results, it was found that while the first implementation showed that only the three items "preparation", "language", and "explanation" had any impact on overall evaluation, the third implementation showed that the overall evaluation was affected by six items: "topic", "handouts", "language", "explanation", "passion", and "homework/review." The increase in items for which significant differences were observed could be considered simply to suggest that only these various items were linked to the overall evaluation. However, given that the results of t-tests for the newly added items yielded significant differences for "topic" and "homework/review", the finding that the implementation of clickers resulted in the "topic" being dealt with in the lessons being deemed more appropriate, and in students reporting that they did more "homework/review" for their course suggests that these had an impact on overall lesson evaluation.

2. Post-Lesson Teacher Reflections

(1) Collocation Analysis

While we have thus far been concerned with the quantitative analysis of student lesson evaluations, we also carried out a lesson reflection exercise involving the teacher in charge of delivering the lessons and another teacher who observed the lessons, and have attempted a qualitative analysis of the resulting conversation. The method of analysis employed is known as collocation statistics. "Collocations" here refer to "words often used in combination with one another that form natural connections." For this study, natural word linkages and frequently used combinations have been tabulated using the word "clicker," from our real-time lesson response system, as a key term. The results are shown in Table 4 (first clicker implementation) and Table 5 (third clicker implementation). Note that the "Left" column in the table indicates the number of instances when each word appeared to the left of "clicker", while the "Right" column indicates

Table 4. Collocation statistics breakdown in the first implementation

Extracted word	Part of speech	Total	Left	Right
Use	Verb	8	0	8
Receive	Verb	3	0	3
Essentially	Adverb	3	2	1
Comprehension	Noun	3	0	3
Reply	Noun	2	0	2
Confirmation	Noun	2	1	1
Effect	Noun	2	0	2
Mindset	Noun	2	0	2
This time	Noun	2	2	0
First	Noun	2	1	1
Scale	Noun	2	2	0
Operation	Noun	2	1	1
Last time	Noun	2	1	1
Change	Verb	2	0	2

Table 5. Collocation statistics breakdown in the third implementation

Extracted word	Part of speech	Total	Left	Right
Today	Noun	10	8	2
Clicker	Noun	8	4	4
This time	Noun	6	5	1
Lesson	Noun	6	2	4
Usage	Noun	5	1	4
Axis	Noun	5	2	3
Ugh!	Interjection	4	4	0
I see.	Interjection	4	4	0
KitKat	Noun	4	1	3
Effect	Noun	4	0	4
Use	Verb	4	2	2
Problem	Noun	4	0	4
Meaning	Noun	3	3	0
Result	Noun	3	0	3
Story	Noun	2	0	2
Stress	Noun	2	0	2
Number one	Noun	2	1	1
Student	Noun	2	1	1
Feeling	Noun	2	0	2
Opposite	Noun	2	2	0
Place (on)	Verb	2	0	2
Absolute	Noun	2	2	0
Instructor	Noun	2	2	0
Really	Adverb	2	2	0
Employ	Verb	2	0	2

the number of instances of each word to the right of "clicker."

Our collocation analysis results showed that the term "clicker" did not simply start being referred to more frequently, but shifted from the context of words like "use" and "receive" to "lesson", "usage", and "axis." In other words, there was a shift from words pertaining to the function of the clicker to expressions situating it as a tool in the context of the lesson. Next, we extracted the specifics of the speech content.

(2) Specific Speech Content

Since any discussion derived from the above collocation analysis will ultimately be based on results at the level of individual words, we extracted and considered the specifics of speech content. First of all, let us look at two speech excerpts from the teacher in charge of the lesson, taken from the lesson reflection exercise conducted after the first clicker implementation

Table 6. Specific speech content from the lesson reflection exercise in the first implementation (1)

When drawing up today's problems, I thought I might be able to try to create some problems that were to some degree premised on having the clicker. That was a big difference in my mind, thinking that I could essentially measure class participation and comprehension in real-time with the clicker. Mistakes I made by going too far in the opposite direction were things like watching for reactions after trying to have them work on a calculation.

Lecturing a hundred students is … all the more reason … ugh, it's just that, although it feels mentally like that's what's happening, and although as an item I'm able to use it as my own technique, it's just that… this time I thought it was really interesting since we had the clickers, but since the outcomes are so different…the index used to be clear, such as the number of people who passed that test …

Table 7. Specific speech content from the lesson reflection exercise in the third implementation (2)

Getting to this point, I feel like I've gotten the hang of this thing, inside me. Um, the feeling I've got inside is that, probably unlike before, this time the clicker had a story to tell. "Since the clicker follows this order, I'll give them this problem…" And in fact, on top of that, I actually wanted to say this, it pointed out that this was also something to review. Inside myself, when I was actually making a problem for this clicker, I made a note of A, and it reminded me. […] For the first time, I've got this feeling inside that the clicker has a story to tell.

This time, I was sure about putting the clicker problem first and then providing the explanation later. When I think about where I put the axis [of the lesson], I guess it was actually the clicker that provided the axis.

(Table 6). At this point, the teacher in charge was not yet familiar with the clicker's use, and had the sense of being at its mercy. In other words, the teacher appears to have been preoccupied with concerns such as creating problems "premised" on the use of the clicker and measuring comprehension in real time.

In contrast is the excerpted speech from Table 7 with the teacher in charge of the lesson reflection exercise conducted after the third clicker implementation. At this stage, a clear difference from the first implementation is that the clicker "had a story to tell." In other words, as also evidenced by this remark, the teacher who had previously been worried about "how to use the clicker" seems to have learned to use it as an "axis" for structuring a series of lessons. This presumably suggests that not only had the teacher in charge gained proficiency, but that the teacher's

entire way of engaging with the lesson had changed. In more concrete terms, prior to the implementation of the clicker, it appears that there were no attempts to understand student comprehension or reaction in real time; however, using clicker's enabled real-time understanding, and this may have provided a basis for enabling the restructuring of the lesson.

Conclusions

As a result of this study, it was found that in courses involving practical exercises for larger class sizes, the implementation of a real-time lesson response system can improve student lesson evaluations, teacher lesson delivery skills, and lesson format. In this context, teacher practical-lesson delivery skills refer to not only tool literacy for using the real-time lesson response system, but also the teacher's mode of

engaging students with the lesson itself. In this study, the implementation of a real-time lesson response system not only resulted in the improvement of lesson evaluations and lesson content, but may also be considered to suggest possibilities for a new form of active learning in larger classes.

While this study carried out an analysis of applied lesson practice using a real-time lesson response system, no data has been gathered with reference to a control setting, that is, to lessons where such systems have not been used. Moreover, the results of this study were obtained in the context of the highly specialized subject of medical fee billing practice; therefore, it will be difficult to generalize the conclusions to the various other modes of education being implemented within higher education. In the future, it is hoped that further insights may be obtained through comparison with lessons not involving real-time lesson response systems as well as with the implementation of such systems in the context of other subjects.

In this research, it did not compare with the control group which is not using Real-time Response System. Therefore, it is not possible to say that the effect of Real-time Response System could be purely measured. By comparing with the control group in the future, the effect of Real-time Response System will become clear.

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