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Preliminary Study on Learning Assessment by Using Problem Posing in an Online Course as an Alternative Method of a Conventional Examination

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Abstract: In 2020, due to the COVID-19 pandemic, universities had to conduct online courses, and instructors were required to use assessment methods other than conventional examinations. This paper reports a preliminary study on learning assessment by using problem-posing in an online course. We investigated whether students who learned well from the course succeeded in solution-based problem-posing without specific training on the skill. The results revealed that students who did well on tests during the course achieved high scores, indicating the possibility that this assessment method can provide an alternative to conventional examinations.

Keywords: Problem-posing, assessment, online course

1. Introduction

In 2020, many aspects of everyday life, including education, were changed by the COVID-19 pandemic. Due to governments imposing lockdowns or issuing stay-at-home requests, universities and other types of schools worldwide had to conduct classes using video-conferencing software or as online courses without sufficient time to prepare. Since online courses using learning management systems (LMSs) and blended learning, which combines classroom methods and online courses, have been widely accepted in recent years, many people could have potentially managed to provide instruction or to learn during the disruption caused by the pandemic. However, for many online courses, instructors were required to their change usual assessment methods from conventional examinations. Students generally take such examinations in a classroom, solving problems with pencils and paper, without referring to any materials (e.g., textbooks or online sources). However, since the pandemic prevents students from gathering in close spaces, such classroom-based, restricted examinations are not viable to use for assessment. Therefore, in the current situation, instructors need alternative assessment methods that account for the assumption that students may refer to any available materials.

This paper reports a preliminary study on learning assessment in an online course, which can serve as an alternative to conventional examinations. Here conventional examinations are supposed a task to solve problems similar in some aspects to but different in the others from those used in instruction or learning. We adopted a problem-posing task, in which students created new problems based on ones they had studied during the course. We investigated whether students who learned well from the course completed the task successfully without receiving additional training.

2. Theoretical Background

2.1 Problem-posing and its Use as an Assessment Tool

The most traditional learning activity is to solve problems provided by a teacher or from textbooks. However, in addition to problem-solving, problem-posing, by which learners create problems by themselves, has also been identified as an important educational activity. Problem-solving and problem-posing are not entirely different cognitive activities but are closely related. Experimental findings have shown a correlation between problem-solving ability and problem-posing performance (e.g., Ellerton, 1986; Siver & Cai, 1996). Problem-posing has also been used during instruction and learning activities in actual classroom settings, and its effects have been confirmed (e.g., Hirashima, Yokoyama, Okamoto, & Takeuchi, 2007; Yamamoto, Kanbe, Yoshida, Maeda, & Hirashima, 2012).

The use of problem-posing to assess students' understanding and transfer of knowledge has also been discussed (Mestre, 2002), with some studies empirically investigating problem-posing as an assessment tool (Cai, Moyer, Wang, Hwang, Nie, & Garber, 2012; Mishra, & Iyer, 2015). However, there is a simple but critical issue to using problem-posing in assessment, in that it is a difficult task to perform. Students tend to create simple problems and occasionally fail to compose appropriately solvable problems, even when they can easily solve problems in the same task domain (Kojima, Miwa, & Matsui, 2013a; 2013b). In fact, Cai et al. (2012) found that only a small number of students posed valid problems during an assessment. To facilitate posing problems, Mishra and Iyer (2015) asked students to perform the task in pairs. These findings imply that merely adapting a problem-posing task to be an assessment would not be appropriate, as many students could fail such an assessment without receiving problem-posing training.

Our previous study confirms that many students succeeded in a type of problem posing (Kojima, Miwa, & Matsui, 2013a). This type was solution-based problem-posing (Hirashima, et al., 2007), in which students compose problems that can be solved with a solution specified. The problem-posing practice by Hirashima et al. has adopted this type and successfully facilitated children's learning of arithmetic word problems in both of problem-solving and -posing skills. Solution-based problem-posing by students can be effectively facilitated by showing examples (Kojima, & Miwa, 2008). Thus, this type of problem posing was expected to be feasible in assessing student learning.

2.2 Student Behaviors and Online Course Performance

Many studies have explored relationships among attendance, engagement, and other student behaviors related to online courses and learning performance (e.g., Goda, Yamada, Kato, Matsuda, Saito, & Miyagawa, 2015; Mogus, Djurdjevic, & Suvak, 2012). Findings from these studies revealed that students who frequently viewed courses and worked on their assignments appropriately tended to show high performance levels, and students who finished each assignment at an appropriate pace performed higher than those who procrastinated. Accordingly, we investigated student performance in a problem-posing task as a course assessment and student behaviors, as recorded in log data in an LMS.

3. Methods

3.1 Course Overview

The investigation was conducted in 2020, during a database course in the department of information and electronic engineering in the author's university. This 14-week course included 13 lectures and practice performing database operations with SQL. Each lecture was presented via an LMS each week and comprised an instructional video, worksheet, and test. Students could view each lecture anywhere and at any time after they were presented. Each worksheet included questions and students were to answer by referring a textbook. Each test included 7–10 problems, and each problem was randomly select from a set of 3–6 problems. Thus, the tests included different problems for each student who took it. Table 1 shows an example of a set in a test. Students were instructed to take each test repeatedly until they answered at least 80% of the problems correctly (we call this *pass*) as a requirement for course credit. They were told that the number of tests in which they scored 100% would be added to the final course score. They were encouraged to pass each test in the week it was presented.

After the last lecture was presented, an instructional video for the course examination was also provided. The examination included six problems (*bases*), each of which was used in one of the tests from the 13 lectures. Students were asked to pose a new problem from each of the six bases, which had a solution with a structure the same as the base, but a different *situation*. Here, situations denote surface information about contextual settings such as "*customers order items when online shopping*." The first of the six bases is presented as "(a)" in Table 1. The instructional video explained how to pose a problem identical to the base in solution, but different in situation, by using the set presented in Table 1. This explanation was intended to provide examples of solution-based problem-posing. Mere duplication of any problems from the 13 tests administered during the course or the textbook was not acceptable. Students were also encouraged to create situations that differed from any of the bases. The video directly identified situations students were to avoid. They were then presented a rubric for assessing solutions and situations, which is illustrated in Table 2. Students were encouraged to enhance solutions, if possible, and they composed their problems in document files and then submitted using the LMS assignment function. This assignment function enables an instructor to mark a student's response using a rubric and show the rubric to the student before submission and after marking.

In 2019, the course was conducted using blended learning. This course was identical to the 2020 course, except all lectures and practice took place in a computer room during the class hour, the lecture provided instructions directly in the room, and the examination used conventional methods (i.e., 20 problems created by altering ones from the tests administered throughout the course). Data from the 2019 course were also used in analysis described below.

Table 1. *Example of a Test Set (Problem 4 on the Sixth Lecture Test)*

(a) A table *employee* has columns of *employee_id*, *name*, *office_id*, and *service_years*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement. SELECT name, office_id FROM employee WHERE office_id IN ("E1", "E2", "E3") Solution) $\pi_{\text{name,office\_id}}(\sigma_{(\text{office\_id="E1"})\vee(\text{office\_id="E2"})\vee(\text{office\_id="E3"})}\text{employee})$
(b) A table *student* has columns of *student_number*, *name*, *department_id*, and *gpa*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement. SELECT name, department_id FROM student WHERE student_number IN ("19E221", "19E222", "19E223") Solution) $\pi_{\text{name,student\_number}}(\sigma_{(\text{student\_number ="19E221"})\vee(\text{student\_number ="19E222"})\vee(\text{student\_number ="19E221"})}\text{student})$
(c) A table *order* has columns of *order_id*, *user_id*, *item_id*, and *number*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement. SELECT user_id, item_id FROM order WHERE item_id IN ("S500CK1", "S500CK2", "S500CK3") Solution) $\pi_{\text{user\_id,item\_id}}(\sigma_{(\text{item\_id="S500CK1"})\vee(\text{item\_id=" S500CK2"})\vee(\text{item\_id=" S500CK3"})}\text{order})$

Table 2. *Rubric for Assessing Student Problems*

	0 points	1 point	2 points
Solution	Simpler than base, inappropriate solution, or duplication of tests or textbook	Identical to base, or different but of equivalent complexity	Successfully enhanced base
Situation	Identical (employees' offices, student enrollment, order in online shopping, library books, or bank accounts)	Different	

3.2 Data Analysis

Each problem's solution and situation were scored using the rubric shown in Table 2. Here, we separately calculated scores for the solutions and situations of the six problems each student created. Total scores for the solutions and situations were used to measure examination performance in the 2020 course. Some examples of student problems were shown in the Appendix. In the 2019 course, performance was measured based on the total number of problems each student correctly solved.

Student behaviors in the course were analyzed with log data for the 13 tests. Each single test response was indexed with two dimensions: time and pass. For the time dimension, a response for a test was labeled with *the first week* (F) if it was submitted within a week after the test presented, *the last week* (L) if submitted within a week right before the deadline (2020)/the day the examination was conducted (2019), or *the middle weeks* (M) if submitted between the first and last weeks. For the pass dimension, each response was labeled with *passed* (P) if the maximum test score before the response was already 80% or higher, or *not passed yet* (N) if the maximum score was lower or it was the first response for the test.

Students who submitted many responses, especially F and P responses, could be regarded as those who learned well. Accordingly, it was predicted that numbers of F and P responses would be positively correlated with examination scores. Similarly, students who submitted many L and N responses could be regarded as procrastinators. Accordingly, it was predicted that L–N responses would be negatively correlated with examination scores.

4. Results

In total, 44 students enrolled in the database course, and 27 of them submitted the examination in 2020. In 2019, 56 out of 58 students took the examination. Table 3 shows the examination scores, and Figure 1 presents the average numbers of responses submitted to a test from a student. For each lecture, students in the 2020 course submitted about six test responses, compared to about seven in 2019.

We analyzed correlations between examination scores and number of responses by calculating Spearman's rank correlation coefficients, which are shown in Tables 4, 5, and 6. As presented in these tables, situation scores were not correlated to test responses, whereas solution scores were significantly correlated to F responses, marginally correlated to P, F–N, and F–P. Furthermore, solution scores were negatively correlated to L and L–N responses. Examination scores in 2019 were significantly correlated to P, M–P, and L–P, and marginally correlated to F–P. They were also marginally, negatively correlated to L–N. These results confirm that F and P responses were negatively correlated to examination scores and L–N.

Table 3. *Examination Scores*

	Average	SD	max	min
Solutions 2020	3.44	1.77	8	1
Situations 2020	3.93	1.76	6	0
Number correctly solved 2019	11.14	3.64	19	3

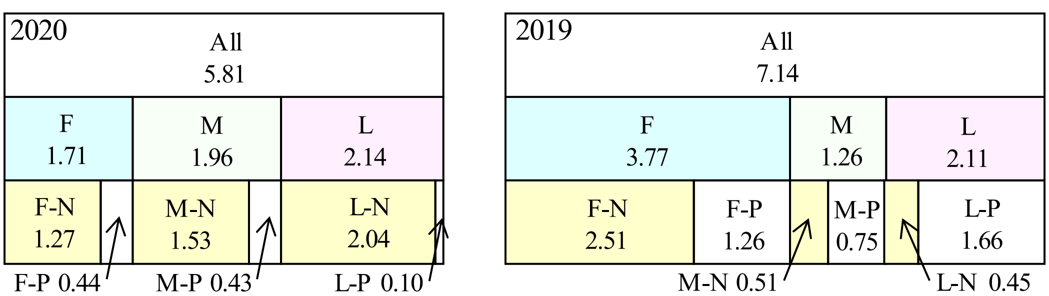

Figure 1. Average number of responses for a test from a student.

Table 4. *Correlations between Examination Scores and Number of Responses (Solutions 2020)*

time	pass	numbers of responses	correlations	test statistics	p-values
All		5.81	.098	0.49	.630
	N	4.84	-.203	1.20	.241
	P	0.97	.340	1.81	.082
F		1.71	.397	2.16	.040
	–N	1.27	.367	1.97	.060
	–P	0.44	.341	1.81	.082
M		1.96	.029	0.15	.885
	–N	1.53	.028	0.14	.890

	–P	0.43	.212	1.08	.289
L		2.14	-.400	2.18	.039
	–N	2.04	-.431	2.39	.025
	–P	0.10	-.137	0.69	.495

Table 5. *Correlations between Examination Scores and Number of Responses (Situations 2020)*

time	pass	numbers of responses	correlations	test statistics	p-values
All		5.81	.186	0.95	.352
	N	4.84	.028	0.14	.891
	P	0.97	.021	0.11	.915
F		1.71	-.008	0.04	.969
	–N	1.27	-.014	0.72	.943
	–P	0.44	.143	0.72	.476
M		1.96	.034	0.17	.867
	–N	1.53	.055	0.28	.784
	–P	0.43	-.104	0.52	.606
L		2.14	-.031	0.16	.877
	–N	2.04	-.062	0.31	.757
	–P	0.10	-.130	0.66	.517

Table 6. *Correlations between Examination Scores and Number of Responses (2019)*

time	pass	numbers of responses	correlations	test statistics	p-values
All		7.14	.218	1.64	.106
	N	3.77	-.211	1.59	.119
	P	0.97	.382	3.04	.003
F		3.77	.140	1.04	.303
	–N	2.51	.054	0.40	.689
	–P	1.26	.238	1.80	.077
M		1.26	.089	0.66	.514
	–N	0.51	-.213	1.60	.115
	–P	0.75	.338	2.64	.011
L		2.11	.308	2.38	.021
	–N	0.45	-.226	1.71	.093
	–P	1.66	.450	3.70	.001

5. Discussion and Conclusions

The results described above revealed that students who took the LMS tests during the week they were presented and submitted many responses after passing had high examination scores in terms of the solutions they composed. Similar trends were observed in the conventional problem-solving examination; however, no such trends were observed in terms of situations. That may have been because no students found it difficult to set situations, whereas composing solutions depended on how well they had learned the course material. These findings suggest the possibility that assessments using solution-based problem-posing can serve as an alternative to conventional examinations.

As Table 3 shows, the average solution score for student problems was 3.44 and the max was 8, although a perfect score was 12. In all, the students posed 140 problems, but only 6 problems of them successfully enhanced the solutions. Our previous studies (Kojima & Miwa, 2008; Kojima, Miwa, & Matsui, 2013a) demonstrated that novice students pose few problems with enhanced solutions without first receiving supportive interventions or training. In fact, a few problems received 0 point for their solutions, because they failed to compose appropriate solutions as a result of challenging in enhancement. This can be a design issue related to using problem-posing as an assessment method.

Although this was not the central issue in the current study, student behaviors were different between the 2019 (blended) and 2020 (entirely online) courses. As illustrated in Figure 1, numbers of F and P responses were lower in 2020 than in 2019, while there were more L–N responses. The higher number of P responses in 2019 may indicate that students had to practice problem-solving for the examination. Few F and many L–N responses may indicate that there were more procrastinators in 2020. It is well known that many students drop out of online and distance learning courses, and it has been well argued that self-regulation strategies are more crucial in the situation (e.g., Goda et al., 2015).

As described in Section 2, problem-posing is regarded as promising an assessment tool. Mestre (2002) suggested problem-posing be used as a diagnostic tool for pedagogical purposes. In fact, some student problems in this study exposed inappropriate understanding of database-related concepts (e.g., functional dependencies and lossless-join decomposition). Such problems received 0 points for their solutions. However, other student problems with zero-point solutions suffered from minor errors, such as inappropriate directions for inequalities (score ≤ 60 and score ≥ 80). Although this study preliminary evaluated solutions with simple rules, as described in Table 2, we must design an evaluated method that can effectively detect and distinguish minor and essential errors in future work.

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Appendix

Examples of problems posed by students from (a) in Table 1

A table *furniture* has columns of *furniture_name*, *theme*, *size*, *category*, and *color*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.

SELECT furniture_name, category FROM furniture WHERE theme IN (“cute”, “simple”, “chic”)

Solution) $\pi_{furniture\_name,category}(\sigma_{(theme=”cute”)\vee(theme=”simple”)\vee(theme=”chic”)}furniture)$

(1 point for the solution and 1 point for the situation)

A table *human* has columns of *id*, *name*, *nationality*, and *age*. A table *android* has columns of *id*, *produced_date*, *nationality*, and *age*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.

SELECT id FROM human NATURAL JOIN android WHERE nationality IN (
SELECT nationality FROM human WHERE nationality IN [“Japan”, “USA”, “Russia”, “China”]
OR
SELECT nationality FROM android WHERE nationality IN [“Japan”, “USA”, “Russia”, “China”]
) AND human.age < 65

Solution)

$\pi_{id}(((\sigma_{(nationality=”Japan”)\vee(nationality=”USA”)\vee(nationality=”Russia”)\vee(nationality=”China”)}human)\vee(\sigma_{(nationality=”Japan”)\vee(nationality=”USA”)\vee(nationality=”Russia”)\vee(nationality=”China”)}android)\wedge(age<65))human*android)$

(0 points for the solution and 1 point for the situation)