COLLABORATIVE TESTING STRATEGIES IN A COMPUTING COURSE

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ABSTRACT

Beyond cognitive competence, other abilities are relevant to labor market nowadays, including critical thinking, self confidence, teamwork and communication. It is then important to introduce in the learning process practices that contribute to both the acquirement of knowledge and the development of soft skills. A prominent answer to this challenge is the use of the collaborative learning, where students work together to solve a problem or complete a task. In this paper, we present three strategies to implement collaborative testing in class. We also evaluate the application of such strategies in a computing course in order to provide evidences of their effectiveness compared to traditional tests. We found that collaborative testing contributed not only to improve students' performance in tests, but have a positive impact on perceived learning and students' satisfaction.

KEYWORDS

Education, Computing, Collaboration, Testing, Learning, Satisfaction

1. INTRODUCTION

Technology is increasingly getting into people's lives and becoming one of the keys of economy nowadays. Governments are trying to impulse its economy by developing the industry and using science to aggregate value to its products and services. Besides the importance of technical background, there are other skills that need to be developed during the education process. Wagner (2008) describe seven skills that companies expect students to develop, as follows: critical thinking and problem solving, collaboration across networks and leading by influence, agility and adaptability, initiative and entrepreneurialism, effective oral and written communication, accessing and analyzing information, curiosity and imagination. In other work, Anderson (2014) identified important skills such as flexibility, communication, cooperation, emotional maturity, and initiative.

Education institutions must be prepared for this demand and for the necessary training of students, in order to respond to economic and social developments in the 21st century. According to Henderson and Dancy (2011), a barrier in the education process is the lack of knowledge about how to effectively use the available instructional ideas and strategies. Professors are investigating different ways to improve learning, considering the development of cognitive and non-cognitive skills, by using collaborative activities during the course. Student-centered instructional strategies are proving to be more effective in improving students' conceptual understanding, knowledge retention, and attitudes about learning than traditional methods that do not include student participation (Kober, 2015).

Collaborative testing is a method in which students work together while taking an evaluative exam. Testing is a means to identify whether teaching is effective and how well the student comprehends subjects. Important outcomes, related to enhancement of students' learning, are been generated through investigations of the use of collaborative testing in distinct contexts (Björnsdóttir et al, 2015; Cantwell et al, 2016). For instance, Willey and Gardner (2012) reported the capacity that collaborative frameworks have to develop an effective and integrated learning experience for students. Shen et al (2008) found that collaborative testing enhanced interactions among students and increased the perceived learning. In the present paper, we present three collaborative testing strategies and discuss relevant results associated to their application in a computing course.

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2. COLLABORATIVE TESTING: STRATEGIES AND APPLICATION

In this section, we explain the selected collaborative testing, and present the experiment design and results.

2.1 Collaborative Testing Strategies

Three collaborative testing strategies were designed, as follows: "Question Revision", "Question Discussion" and "Pair Work". Figure 1a shows the scheme of the "Question Analysis" strategy. The strategy consists of using knowledge acquired during a test part to help solving other parts of the test. The steps of the strategy are: 1) Each student answer question A individually; 2) Instructor separates students into groups in order to discuss their question and understand their mistakes, without changing their answer; 3) Students separate the groups and solve question B individually, which uses the same idea of question A but in a more complex context. To get the expected result it is important that students discuss question A and try to figure out the answer for it based on what each student wrote and on the discussion itself.

Figure 1b present the scheme of the "Question Discussion" strategy. The strategy tries to use the power of initial discussions to accelerate the reasoning of students. The steps of the strategy are: 1) Instructor forms groups and give them some time to discuss the main idea of Question A; 2) Students separate from the groups and solve question A individually, but using the discussed ideas; 3) Students solve question B individually, which uses the same idea of question A but in a more complex context. The purpose of this strategy is just to accelerate the rationality behind the question, and not have a group question.

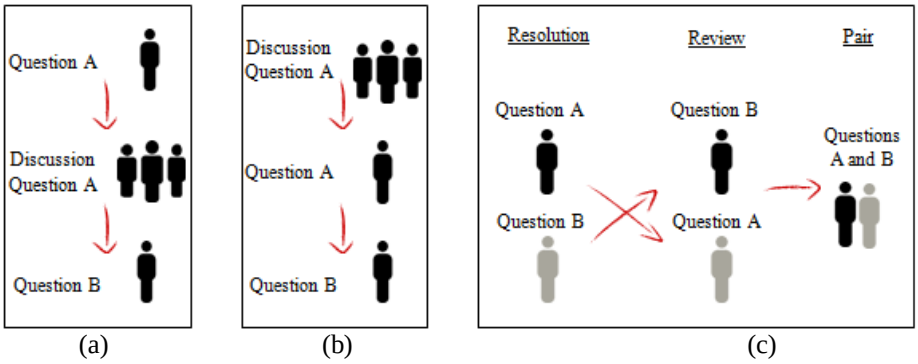

Figure 1. Collaborative testing strategies. a) Question Revision. b) Question Discussion. c) Pair Work

The scheme of the "Question Discussion" strategy is shown in Figure 1c. With this strategy, students have the chance to correct some mistakes during a test. The strategy uses the power of a peer review to give students the possibility to develop their critical thinking and discussion skills. After instructor separates the class into pairs, the steps of the strategy are: 1) Each student of a pair receives one different question and solve it individually; 2) After a stipulated time, students change tests with their pairs and start the review process; 3) Each pair discusses the best answer for each question and hand over the test. This strategy does not require dependences between questions, but it is important to define pairs to avoid them being uneven.

2.2 Experiment Design

The experiment was taken place at an engineering school, during the course of "Data Structure and Algorithms" from the department of Computer Science. We applied the three collaborative tests in a class of 46 students. An important part of the experiment was the selection of subjects for each collaborative strategy. We used "arrays and recursion" topic with "Question Revision" strategy, "linked list" topic with "Question Discussion" strategy, and "queue and stack" topic with "Pair Work" strategy. To evaluate the effectiveness of the proposed strategies, we considered the following aspects: students' performance, perceived learning, and satisfaction of students. The first one was considered to test the concept that students would have better grades if tests involve some collaborative activity. The second one was to understand if students taking

collaborative tests would have a better perception of learning than taking traditional exams, whilst the last one is to have a sense if students liked the proposed activities.

In order to evaluate students' performance with "Question Revision" and "Question Discussion" strategies, we divided the class into two random groups, each one with half of the class. One group (called experiment group) used the collaborative strategy, while the other group (called control group) used traditional test format. For the "Pair Work" strategy, the whole class participated in the collaborative activity (configuring the experiment group) and the control group was a class in the previous year that performed a traditional test with the same questions.

The aspects of perceived learning and students' satisfaction were evaluated based on the perception of students who participated in the collaborative activities. Evaluation sentences are shown in Table 2. Sentences L1 to L6 were regarding perceived learning, while sentences S1 and S2 were about students' satisfaction. Students used a 5-point likert scale (with the values: strongly agree, agree, neutral, disagree, and strongly disagree) to assess sentences L1 to S1. The last sentence S2 had "yes" or "no" as possible answers. Sentences L1 to S1 were assesses by all students in the beginning of the course, considering their experience with traditional tests. All sentences were evaluated after each collaborative test but only by students in the experiment group, who really experienced the collaborative strategy.

2.3 Results

Performance results for each collaborative test are shown in Table 1 using the mean of grades (0 to 10.0) of students in experiment group (with collaborative test) and control group (with traditional test). Regarding "Question Revision" strategy, we observed that experiment group had lower performance in Question A compared to control group. It was not a problem, since the strategy include a step to discuss Question A but without changing it. The discussion was expected to positively influence the grades in Question B (more complex than Question A), which was in fact observed with a 10% of performance improvement. Notice that grade mean in Question B was similar in both groups, however the discussion really helped the experiment group to overcome their difficulties and reach better results.

Table 1. Performance of students

Strategy	Group type	Question A	Question B
Question Revision	Experiment group	6.7	7.3
	Control group	8.5	7.1
Question Discussion	Experiment group	9.1	8.3
	Control group	8.2	8.1
Pair Work	Experiment group	8.3	8.1
	Control group	6.4	6.5

Table 2. Sentences and results about perceived learning and students' satisfaction

Id	Sentence	Question Revision	Question Discussion	Pair Work
L1	The test positively contributed to my learning process.	13%	6%	16%
L2	The test made me realize that I know the subject studied.	16%	15%	15%
L3	With the test, it is possible to learn from answers and comments of my peers.	9%	11%	13%
L4	The test contributed to develop my critical thoughts.	39%	11%	35%
L5	The test contributed to develop my analysis capacity.	6%	10%	12%
L6	The test contributed to develop my self confidence.	7%	12%	6%
S1	I feel anxious doing the test.	-13%	-17%	-6%
S2	I would like to do again this kind of test	87%	78%	79%

Regarding "Question Discussion" strategy, the previous discussion about Question A, before solving it, contributed to a better perfomance of experiment group. The performance of experiment group was 11% higher compared to control group. In Question B, the difference of 3% between the two groups was not expressive enough to conclude that it was due to the discussion or if it is just a normal deviation in the class. So it was not clear is if discussing Question A helped them to figure out the solution of Question B. In "Pair

work" startegy, we observed a performance improvement of approximately 25% in each question. It was expected since the strategy allowed students to change their answers after using the contribution of their peers. Results of the evaluation of perceived learning and students' satisfaction are presented in Table 2, with the percentage representing how much more the collaborative test is higher than the traditional test (assessed in beginning of the course considering the previous experience of students). The result of S2 sentence is a percentage that represents the amount of students that answered "yes" after performing the collaborative test. Analyzing the results, we noticed that all sentences in all tests had higher scores compared to traditional tests, except in case of S1 sentence. We expected that students would feel more anxious during traditional tests; however students were apprehensive in collaborative test because they had never experience that and they do not know if it could negatively affect their grades. Regarding perceived learning, students acknowledged that collaborative tests were better for their learning, especially for developing critical thinking and for assessing the acquired knowledge. The majority of students, approximately 80%, indicated that they would like to have other opportunities with collaborative testing.

3. CONCLUSION

We presented three collaborative testing strategies and applied them in a computing course. Based on the proposed strategies, adapted versions and even new strategies can emerge, which are extremely valuable for educational community. The application of collaborative testing is possible even in the presence of other forms of evaluation; in our case, we also have traditional tests and practical laboratories. It may be difficult to select the strategy more suitable to the current context, given aspects as definition of questions and organization of class time. The evaluation of strategies is also a challenge, since it depends on several factors including nature and difficulty of questions, time given for each test, context and academic demands of students, and the way the strategy is applied. Considering our results, the approval of the usage of collaborative tests by students, aligned to the students' perception that such tests were more effective than traditional ones in term of learning, are powerful evidences of the potential of collaborative testing. The collaboration itself brings the opportunity to students practice other abilities, such as to expose ideas, to negotiate, and to convince others. Collaborative testing, in turn, contributes not only help students to learn more about technical subjects, but also to improve their non-cognitive skills as communication and teamwork. As future work, we intend to apply distinct collaborative testing strategies and to investigate other kinds of effectiveness evaluation.

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