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Optimizing formal working teams' effectiveness extracting data from Multiple Choice Questionnaires

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Abstract
As individuals comprising working groups possess their own personalities and abilities, each of them will show a particular behavior when interacting in an active learning process. Heterogeneous teams of three or four students, where strong and weak students could work together and weak students could be tutored by strong students, would avoid the creation of unbalanced teams. This paper proposes a methodology for optimizing working groups characteristics extracting information from data collected in MCQ (Multiple Choice Questionnaires) using a soft hybrid inductive approach combining traditional classroom with Flipped Classroom, Gamification and Peer Instruction. On the one hand, a gamification approach will allow the professor to boost the previous study of the subject and those students with good knowledge of the right answers will try to convince those partners which are not sure about theirs in a second round of answers. Extra marks will be gained by those students who correct their partners. On the other hand the results obtained from these tests could supply key information with respect to the students' behavior and psychology. This would help the teacher to distribute the students in the creation of effective formal working teams in future learning activities. For instance, this method could optimize the working groups' global performance in a subject where students will be assessed in a group activity such as a cooperative or coordinated project with several partners. A quantitative tool for the creation of optimized student teams for activities programmed at the second term of the subject is described.

Keywords: Working teams, Inductive teaching, optimizing, MCQ.

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Introduction

The use of strong inductive methods such as Team-Based Learning (TBL) (Michaelsen et al., 2009), Problem-Based Learning (PBL) or Project-Based Learning (PBL) (Prince & Felder, 2007), brings the necessity of forming working groups where students with different characteristics will have to work together, cooperatively or well-coordinated in order to achieve a difficult objective. Nevertheless, as individuals comprising the groups possess their own personalities and abilities, each of them will show a particular behavior when interacting with their partners in the active learning process. Oakley et al. (2004) suggested to form heterogeneous teams of three or four students, where strong and weak students could work together and weak students could be tutored by strong students. Strong students would reinforce their knowledge and weak students would have a better learning experience. At the same time this would avoid the creation of unbalanced teams, either very weak or very strong. Authors such as Heller (1992), Hake (1998) and Hilborn (1994) had previously found that teams of heterogeneous ability perform better and Layton et al. (2010) developed a web-based system for assigning members to teams by applying a hill-climbing algorithm for optimizing instructor-specific criteria based on students' GPA, interests, schedule compatibility and pairing of underrepresented team members.

Objective

The implementation of modern Flipped Learning methodologies (Bergmann & Sams 2012) combined with Just-In-Time Teaching (JiTT) (Novak et al, 1999) and a gamification approach (Prieto et al., 2014), where previous study must be performed by the student before the classroom and students are rewarded for their activity, can be an optimum setting for obtaining information from the students' behaviors and personalities. Moreover, if a Peer Instruction approach is also added (Mazur, 1997), the teacher could analyze the information obtained from MCQ tests solved individually and by peers in order to predict how these students will behave in future active and inductive learning activities

The creation of formal working groups in an effective way by the teacher could help to reasonably optimize the performance of the group when students discuss, work together and reflect about the results of their problem, case or project.

This paper proposes a method that could optimize the working groups' performance in an hypothetical subject where students not only must pass an exam but also will be assessed in a group activity such as a cooperative or coordinated project with several partners at the end of the course (for instance using Team Based Learning, Problem Based Learning or Project Based Learning methodologies).

Method

It would be necessary to plan and apply the following class scheme for obtaining the information from the students' behaviours (time specifications can be taken as a reference):

- Previous study by the students: materials could be uploaded by the teacher to a LMS platform such as Moodle or Blackboard. The students must carry out a previous study before the class for being able to work after in the main points during classroom (peer instruction, flipped learning).
- Initial MCQ exam about the previous study's materials, performed at the start of each class by each student. 5 minutes for thinking and solving individually could be enough. An alternative is to perform the test in a LMS platform before class.
- Traditional class with explanation of the main points of the lesson during 30 min.
- Then, 10 minutes for thinking and solving again the same MCQ exam in pairs, after discussing and reflecting, the students will have the possibility of changing or maintaining their individual previous answers (peer instruction).
- Discussion and explanation of solutions and doubts by the teacher for 10 min.
- The same procedure should be carried out at each class, each week or each lesson, but always combining different and not repeated pairs of students.
- Analysis of results by the teacher, considering initial answers and answers after discussing in pairs. The following criteria are quantified: influence on partners, change of opinion, result after previous study, result after class, staying wrong and staying right. These data could be used to improve the selection of students comprising formal working groups in future learning activities programmed for the second term of the subject.

The same procedure should be carried out at each class, each week or each lesson, always combining different pairs of students. The proposed idea is based on quantifying the results obtained individually and after discussing in pairs by means of the criteria specified in Table 1.

In Table 2, the characteristic 'Staying right' in the second test (the same answer right in both the first and the second test) has been included with positive +1 mark. Since it seems quite logical that a strong student with the right answer in the first test will stay with the right answer in the second test (and moreover after the professor explanations), it could have been not considered

These characteristics could be assessed in an excel file, programmed for assigning positive and negative points according to table 2, which shows the sixteen possible situations that could occur for each question in the test.

Table 1. Quantification table

Assessed characteristic	Possibilities	Score assigned
1. RESULT AFTER PREVIOUS STUDY (MCQ solved individually)	Understanding reached after previous study, right solution in the first questionnaire	RIGHT
	Understanding not reached after previous study (with problems in previous study or previous study not performed). Wrong solution in the first questionnaire	WRONG
2. RESULT AFTER CLASS (MCQ solved in pairs)	Understanding reached after class, right solution in the second questionnaire	RIGHT
	Poor understanding in class or Teacher gaps in concepts. Wrong solution in the second questionnaire	WRONG
3. INFLUENCE ON PARTNERS (MCQ solved in pairs)	Good influence: rightly convince to other student in the answer to one question	+1
	No influence, both students keep their right or wrong answers in one question without agreeing with each other	0
	Bad influence: wrongly convince to other student in the answer to one question	-1
4. CHANGE OF OPINION (MCQ solved in pairs)	Wrong solution was changed to right solution in the second questionnaire	+1
	No change of opinion, both students maintain their answers to one question	0
	Right solution was changed to wrong solution in the second questionnaire	-1
5. STAYING WRONG (MCQ solved in pairs)	Persistence of wrong solution in the second questionnaire. Poor understanding in class or Teacher gaps in concepts	-1
5. STAYING RIGHT (MCQ solved in pairs)	Persistence of right solution in the second questionnaire. Good understanding in previous study and after class	+1

Table 2. Possible situations at each question of the MCQ

Situation	Stud.	Result after study	Result after pairs	Influence on partner	Change of opinion	Stay wrong	Stay right	Tot.
1	A	RIGHT	RIGHT	0	0	0	+1	+1
	B	RIGHT	RIGHT	0	0	0	+1	+1
2	A	RIGHT	RIGHT	0	0	0	+1	+1
	B	RIGHT	WRONG	0	-1	0	0	-1
3	A	RIGHT	RIGHT	+1	0	0	+1	+2
	B	WRONG	RIGHT	0	+1	0	0	+1
4	A	RIGHT	RIGHT	0	0	0	+1	+1
	B	WRONG	WRONG	0	0	-1	0	-1
5	A	RIGHT	WRONG	0	-1	0	0	-1
	B	RIGHT	RIGHT	0	0	0	+1	+1
6	A	RIGHT	WRONG	-1	-1	0	0	-2
	B	RIGHT	WRONG	-1	-1	0	0	-2
7	A	RIGHT	WRONG	0	-1	0	0	-1
	B	WRONG	RIGHT	0	+1	0	0	+1
8	A	RIGHT	WRONG	0	-1	0	0	-1
	B	WRONG	WRONG	-1	0	-1	0	-2
9	A	WRONG	RIGHT	0	+1	0	0	+1
	B	RIGHT	RIGHT	+1	0	0	+1	+2
10	A	WRONG	RIGHT	0	+1	0	0	+1
	B	RIGHT	WRONG	0	-1	0	0	-1
11	A	WRONG	RIGHT	0	+1	0	0	+1
	B	WRONG	RIGHT	0	+1	0	0	+1
12	A	WRONG	RIGHT	0	+1	0	0	+1
	B	WRONG	WRONG	0	0	-1	0	-1
13	A	WRONG	WRONG	0	0	-1	0	-1
	B	RIGHT	RIGHT	0	0	0	+1	+1
14	A	WRONG	WRONG	-1	0	-1	0	-2
	B	RIGHT	WRONG	0	-1	0	0	-1
15	A	WRONG	WRONG	0	0	-1	0	-1
	B	WRONG	RIGHT	0	+1	0	0	+1
16	A	WRONG	WRONG	-1	0	-1	0	-2
	B	WRONG	WRONG	-1	0	-1	0	-2

On the one hand, each characteristic ('influence on partner', 'change of opinion', 'staying wrong' and 'staying right') can be assessed individually. This will give a different mark in these behaviours for each student. On the other hand, a total mark can be obtained by the addition of all characteristics and a gamification approach can be applied to assign extra marks (for instance 10% of the total mark) (Prieto et al., 2014) to those students ranking with the higher positive total marks. This will encourage students to carry out the previous study and then they will also be able to answer rightly and to positively influence their partners. As each student will score at each question ranging between -2 and 2, a MQC comprising 10 questions will score between -20 and 20 for each student.

Creation of effective formal working teams

These data bring many possibilities for combining students with different abilities and personalities in optimized working teams: not only the right and wrong answers score positively and negatively but also the influence on partners, the change of opinion and a persistent answer can score positively or negatively. A method for achieving well-functioning groups could consist on combining students with different scores in both the global and in each individual characteristic assessed.

For instance, students with the highest positive scores on 'influence on partner' or 'right answer' could be combined with students with the most negative scores on 'staying wrong' or 'right answer' and, at the same time, with students with more neutral scores (in groups of three or more). In the same way, students with the most negative score on 'change of opinion' should not be combined with other students with the worst score on 'influence on partners'. This will also allow the professor to distinguish between weak students that are able to change their ideas and learn from their partners, and weak students who are reluctant to learn from their partners and are persistent in the wrong answer. In the same way it will allow to distinguish between strong students that are able to transmit their knowledge to their partners and strong students who don't have communicative skills to teach their partners.

All in all, a high amount of information would be available for optimizing the creation of heterogeneous working groups or teams. However this proposal should be tested in order to obtain experimental data from real students and to achieve the best results from different score combinations. This will require the use and support of the present TIC technologies (LMS platforms, educational platforms and software, etc.) to make possible the processing of a high amount of data in an effective way by the professor.

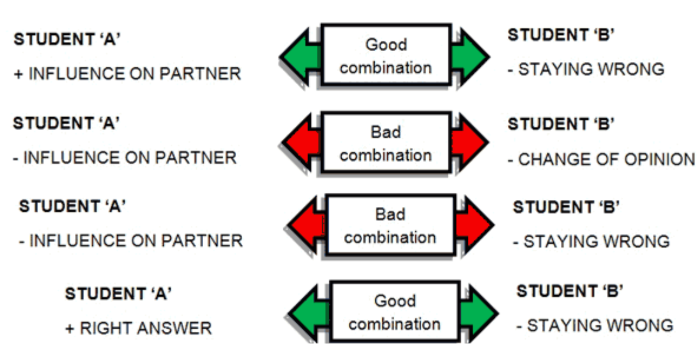

Figure 1. Examples of a good and a bad score combination for forming working groups

An effective solution for achieving heterogeneous teams could be reached applying an iterative algorithm for minimizing the maximum global score obtained from the scores of the students that will form the team. The individual score of each student can be obtained applying table 2 at each question of the MCQ and then adding all the questions' scores. After a total of 'N' questionnaires with 'Q' questions, the student total score n_i can be calculated from equation 1:

$$n_i = \frac{\sum_1^N \sum_1^Q n_{iQ}}{Q \cdot N \cdot 2} \qquad (1)$$

Factor '2' is used for normalizing the students' total score between -1 and 1, where -1 represents total heterogeneity and 1 represents total homogeneity.

Then, the following equation can be applied for calculating the global team scores s_i for teams comprising 'M' members:

$$s_i = \frac{-1}{M \cdot (M-1)} \cdot \sum_{\substack{i=1 \\ j=1 \\ i \neq j}}^{\substack{i=M \\ j=M}} n_i \cdot n_j \qquad (2)$$

Layton et al. (2010) proposed a max-min hill-climbing algorithm for obtaining the optimum solution. In this case, the same strategy can be applied.

Remarks and discussion

- Pairs must be changed and rotated for each questionnaire during the course. A high number of students in class probably won't allow all possible pairs' combinations. For each student, the number of pairs formed must be equal to the number of MCQ performed.
- Key information will be available for forming balanced teams of working groups in later learning activities. The learning process could be much more effective and positive for the whole class.
- Analysis of results from these tests by the professor at the end: is previous study well done? Are main concepts or ideas clear? Is it very easy, very difficult or adequate? Which questions present the main difficulties? Were the questions well chosen? This will give clarity to identify which things should be improved. For instance if many students are convinced wrongly, perhaps there are understanding problems with basic concepts of the subject or the professor should clarify some ideas or concepts.
- A gamification approach can be applied if individual classification add an extra mark for the passing the subject. A new list can be put next to the blackboard after each class to let students know their position. Therefore those students that made the previous study will get higher scores and will be better considered by their partners. The best score is obtained when you rightly convince your partner, so students will make the effort of discussing the questions and convincing one another rightly. At the same time this will lead to a better understanding of the main ideas of the subject.
- It will be necessary to manage a high amount of data. A programmed excel file for assigning automatically the scores and the help of LMS platforms will be essential for applying this procedure.

- Assessment of the working teams' effectiveness: was there a good alignment between teams' performance and results and the selected strategy for forming the teams? Any problem detected should be collected by the professor for improving the methodology.

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