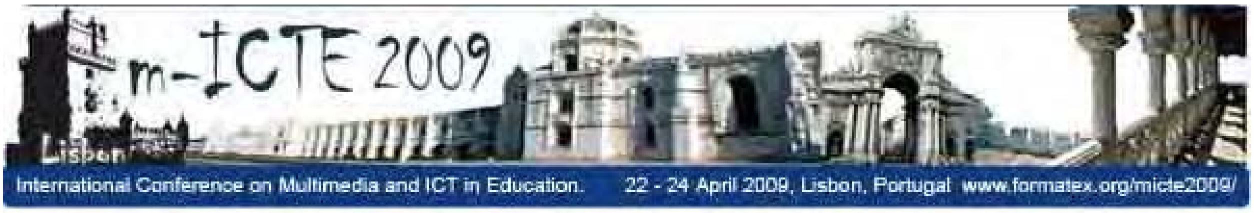

An experience of collaborative learning with students beginning engineering

Arcadi Pejuan

Grup d'Innovació Educativa a la Física (GIEF), Universitat Politècnica de Catalunya (Technical University of Catalonia), Jordi Girona 31, 08034 Barcelona, Spain

This study addresses the question of the effectiveness of a particular collaborative learning activity for problem solving in a class of engineering beginners. The students had to solve a typical problem in two phases: first, they had to solve it (completely or partly) in a totally individual way; after handing their solutions in, they had to solve the same problem in groups. The experience was assessed first comparing each individual solution with that of the group (expressing the individual contribution as a percentage) and second, comparing the mark for the group solution with that obtained for a similar problem in an exam, also considering the individual contribution percentage. Additionally, the students assessed the experience in a questionnaire. The experience was globally positive and effective for learning according to the overall results. Nevertheless, problems have been observed which may be attributed mainly to a lack of real collaboration among the group members, for which an improvement is proposed.

Keywords collaborative learning; problem solving; peer-peer interaction; too early convergence; classroom authority, instructor interaction

1. Introduction

The benefits of collaborative learning are today evident if due attention is paid both to peer-peer interactions [1] and to the well defined roles which tutors and students have to play [2]. Students engaged in collaborative learning enhance their problem-solving and critical thinking skills and, in addition, they learn to work in a team and become more autonomous learners [3]. Especially, collaborative learning is an effective tool as a complement to traditional lectures [4]. It offers the possibility to maintain a face-to-face scenario and yet to take advantage of the higher interactivity of collaborative learning [5]. Indeed, this possibility allows us to consider a face-to-face collaborative learning, instead of a fully on-line computer supported collaborative learning. Face-to-face collaborative learning has its disadvantages, but it has also some advantages in comparison with the fully computer-supported collaborative learning [6], in addition to the practical implementation advantages. Furthermore, collaborative learning has been found to have the strongest positive effect on students' self-reported gains in group skills, problem solving and occupational awareness, but also instructor interaction and feedback are significantly and positively related to these gains, and results also show that active engagement on the part of the instructor is relevant [7].

2. Research question

This study addresses the question of the effectiveness of a collaborative learning activity for problem solving carried out in a class of the 1st course of mechanical engineering. This activity was designed to take into account two aspects. Firstly, there was a large number of students (about 75) attending the traditional class "at the blackboard" of the compulsory subject (Mechanics I). Secondly, we wanted to improve the problem solving skills.

3. Methodology

The students were proposed a typical problem (Fig. 1a) to solve in two phases, once the issue had been dealt with in a traditional class at the blackboard, with model problems. In the first phase, they had to solve the proposed problem (completely or partly) within three days, each student separately, i.e. in a totally individual way. After handing their individual solutions in, they had to get together in groups of preferably three students and solve the same problem in the group. Only the group solution was then assessed and marked. The “digital campus” via internet was used as a way of communication at both phases.

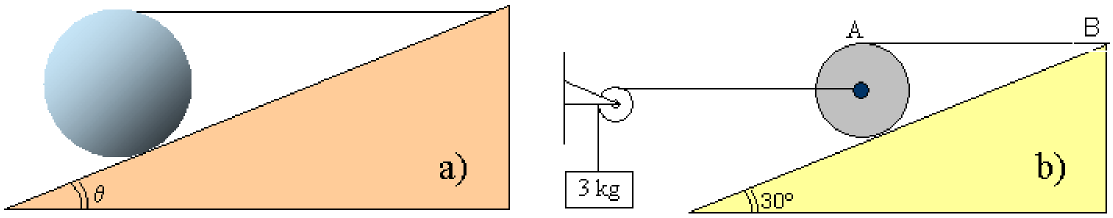

Fig. 1 a) Problem to be solved in the collaborative learning activity (taken from [8]: “Given the mass and diameter of the sphere on the inclined plane with an angle of inclination θ, find the tension in the string holding back the sphere, the normal force on the sphere and the friction with the plane”). b) Problem in the final exam of the subject (“Given additionally the mass and diameter of the roller, find the tension in the string AB and the minimum value of the coefficient of friction for equilibrium”).

Only 53 students decided to take full part in this activity, in addition to some students who only handed in the individual solutions (these were not taken into account for this study).

The assessment of this learning activity is based first on the comparison of each individual solution with that of the group, expressing the connection between both ways of solving the problem as a percentage for each student. In the following, this percentage will be called “contribution percentage”, since it may be considered as the degree of initial contribution to the team work. Second, the individual mark obtained for a similar problem (Fig. 1b) in the final exam of the subject has been compared (a) with the mark obtained for the group and (b) with the same group mark multiplied by the individual contribution percentage. Additionally, the students filled in a questionnaire to assess the experience themselves, scoring three statements from 0 (“I absolutely disagree”) to 4 (“I absolutely agree”). These scores were then normalized from 0 to 100 for more clarity in the results.

4. Results and discussion

Figure 2 shows the distribution of the observed connection between each individual solution and the group solution, expressed as a percentage: 0% means no connection at all, and 100%, identity between both solutions.

Except for the first bar in the chart (which in part will be discussed later), this distribution shows the normal connection to be expected between individual and group solutions, with a cohort of about 22 students (42% of the whole) whose connection to their respective group solution is higher than 70%. Also the result expressed by the first bar in the chart might be (unfortunately!) described as normal: there were as many as 11 students (21% of the whole) who apparently, could not (or hardly) contribute to the group solution (of these 11 students, 4 cases of absolutely no contribution will be discussed later).

Furthermore, Fig. 3 displays a comparison of the individual marks for the exam problem with the group marks for the collaborative activity without any sort of individual weighting (Fig. 3 a), or with the group marks multiplied by the individual contribution percentage (Fig. 3 b). Although the correlation between both pairs of variables is rather poor, the coefficient of correlation for the first pair (involving only the group mark) is clearly better than for the second pair (weighting the group mark according to the previous individual contribution). This leads to the conclusion that, in general, the collaborative team work was a help for the students to positively level out their differences in problem solving skills with that of their better group members; otherwise, the correlation would have been better between the exam marks and the previous individual problem-solving skills, as expressed by the group mark multiplied by the previous contribution percentage, meaning that the team work would not have led to better exam results.

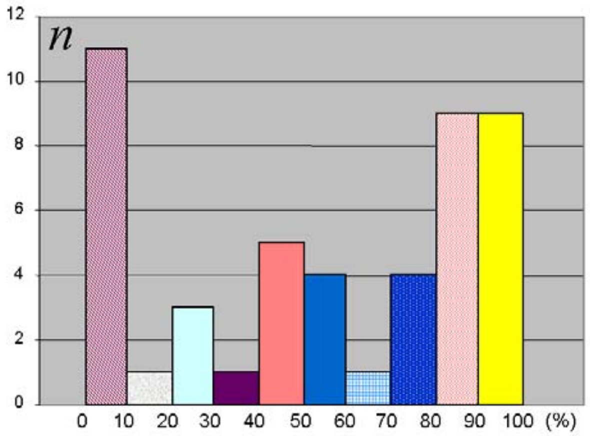

Fig. 2 Distribution of the observed connection between individual solutions and the corresponding group solution (0% = no connection, 100% = identical solutions).

Nevertheless, the correlation can be deemed unsatisfactory also in Fig. 3b, and can be attributed to a partial lack of personal involvement (and personal work) in the collaborative learning activity. An additional cause could be the one described by [9]: teamwork in learning can help to build more abstract representations, but this does not necessarily lead to higher scores in a transfer task, in the case of lack of internalisation of these more abstract representations, in comparison with the results of plain individual work.

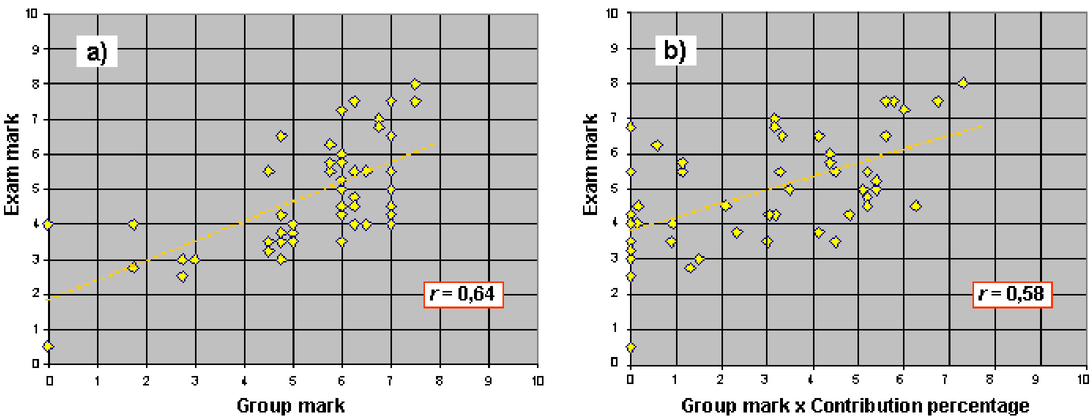

Fig. 3 Better correlation of the individual exam marks with the absolute group marks (a) than with the group marks multiplied by the individual initial contribution percentages (b), in spite of the relatively poor correlations in both.

This is also in agreement with the results from the students' assessment of the activity through the questionnaire. So, to the statement "It helped me to learn to solve problems of Statics" (Fig. 4a), the mean score for their agreement was 61 (over 100), with the scattering shown in the figure. This means that the majority of students perceived the activity as an efficient help to learn problem solving. To the second statement, “It helped me to learn to work in a team”, the most scores were also clearly positive (mean score 54), with the scattering shown in Fig. 4b), so that most students perceived the activity as an acquisition of skills in working together with peers. As for the last statement, “It helped me to take more advantage of the available time for study”, the result was not so positive (mean score: 43 over 100). Nevertheless, this is not so surprising, because for beginners, teamwork demands a lot of more time-consuming tuning with peers in order to coordinate the meetings, to listen to what the others have to say and to try to explain their own points of view. This is indeed an unavoidable drawback of teamwork (and therefore also of collaborative learning), although according to the students’ perception expressed about the two first statements, the advantages make up for this drawback.

Another negative point of this experience of collaborative learning (in addition to the aforementioned rather poor correlation between exam marks and group marks) was the fact that there is a relatively high percentage (9.4% of 53 students) of what could be called a “negative collaboration”: here the individual solution was better than that of the group. This suggests that the involved student had not really provided a full collaboration to improve the group solution (and the mark!). A possible explanation is the ”too early convergence” described in [10], due to the authority structure existing in communities of students and teachers prior to entering into a collaborative learning activity. Also, a remarkable percentage of cases is observed (7.5%, or 4 cases) where there was no connection between the individual solutions and the (better) group solution (in these cases, the collaboration percentage was marked as 0%: see Fig. 2 and Fig. 3b): here should be questioned whether it was the collaboration between the members of the group which led to the better group result, taking also the “factors beyond technology for collaborative learning” according to [5] into account, especially the passive participation induced by the possible anonymity of communication in case of less motivated learners. Another possible explanation could be a lack of teamwork within their own groups.

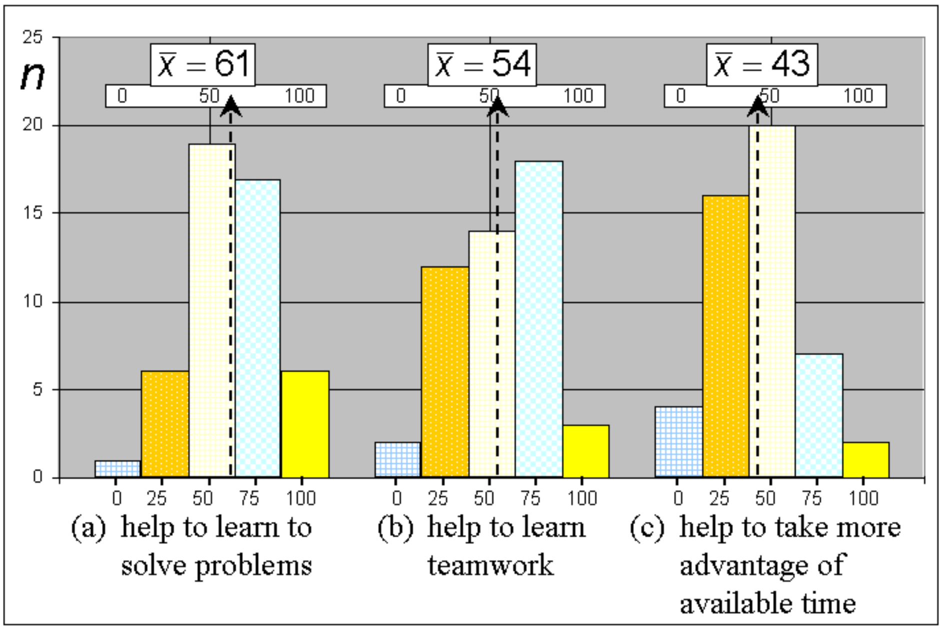

Fig. 4 Mean values and distributions of the students’ scores for the aspects assessed in the questionnaire.

5. Conclusions

The described experience of collaborative learning with students beginning their engineering studies was globally positive and effective for learning, according to two criteria: firstly, the comparison between the group marks and the corresponding exam marks, and secondly, the students' majority perception of the activity as an effective help to learn to solve problems and as an acquisition of skills in working together with peers.

On the other hand, problems have been observed which may be attributed to a lack of real collaboration among the group members and/or to the lack of effort to involve themselves in the activity (unsatisfactory correlation between teamwork marks and exam marks, as well as significant percentages of clear lack of collaboration to the group results and missing teamwork).

These problems call for an improvement proposal, based also on considerations in [5] about classroom authority: a more direct supervision of the second phase described in Section 3 (problem solving in groups) by the instructor, in order to prevent as far as possible that students go the easiest way: the simple adoption of one of the individual solutions (maybe the one that seems to be the most probable one or the one coming from the peer with higher "classroom authority"), without the discussion effort in the group. This is also in line with the considerations in [7] about the importance of the instructor interaction.

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