

# Balancing Competition and Collaboration in a Mixed Learning Method

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**Abstract**—Most of the university level curriculum in engineering environments follows a purposeful formal academic rigor and does not always succeed in offering an in-depth experience that would prepare students for their future professional employment. Due to a constant demand for change in the current engineering teaching methodology, this paper aims to analyze the competitive and collaborative learning approaches and compare them with other previous teaching methods that were used during the Software Project Management course at the "Politehnica" University of Bucharest. Using the experience we gathered with the two aforementioned approaches, we tried a mixed competitive-collaborative learning method, which is also analyzed in this paper.

**Keywords**—Competition-based learning, educational models, mixed collaborative-competition learning, software project management.

## I. INTRODUCTION

THE main branches of learning include: cooperative, competitive and individual learning.

Concerning the group approaches, several benefits have been observed, such as:

- 1) Improved depth of thought by comparing different ideas, as opposed to passive listening.
- 2) Promotion of a better student to student and student to faculty interaction.
- 3) Improvement and innovation in student involvement or teaching environment and techniques.
- 4) Better attendance and a higher level of achievement.

Collaborative learning is a method students can use in order to explore together a subject, raise and answer questions and create a meaningful project. Throughout this paper we will also use the term cooperative learning, which is a kind of collaborative learning, the particularity being better structured activity and individual accountability of each student's work.

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The collaborative approach refers to students that have a common objective, a common task or where each individual depends on and is accountable to each other. Collaboration embodies positive interdependence, supporting students to develop themselves in a collaborative environment, but on the other hand, the negative aspects of collaborative learning is that there is the possibility of an uneven engagement in learning by individual students within a group, translated into uneven contributions to the group's final grade to related work. [7]

In the case of competitive learning students work against each other to obtain a good grade in the detriment of others. As mentioned also in [1] competition is "a social process that occurs when rewards are given to people, on the basis on how their performances compare with the performances of others, doing the same task or participating at the same event." [11] Or as Johnson and Johnson point out: "Competitive learning exists when one student's goal is achieved; all other students fail to reach that goal."

Students realize that certain rewards can be obtained if other students fail, this being the reason for students working against each other in such a learning environment [10].

This approach is inherently different from other approaches, which focus on cooperation among students or working together as individuals.

Individualistic learning implies students working independently to achieve learning goals, not considering what their colleagues do. This paper focuses on the collaborative and competitive group approaches and proposes a way to combine the two in a new mixed teaching strategy.

## II. OVERVIEW OF THE APPROACHES

### A. Collaborative approach

Collaborative learning, has been defined as "a social process through which performance is evaluated and rewarded in terms of the collective achievement of a group of people working together to reach a particular goal" [11].

At a first look, the cooperative learning has several advantages:

- 1) Offers the opportunity of learning how to work with others, as part of a team.
- 2) Allows the students to define their favorite learning style, by working together with peers, rather than working individually.

- 3) Acknowledges that goals in life can be achieved in cooperation with each other.
- 4) A new enjoyable overview upon school and learning for learners.
- 5) Students learn to assist each other in the school and team setting, which can be extremely helpful later on in their professional careers.

Pressel [2] believed that cooperative learning helps children increase self-esteem, intrinsic motivation and develop positive attitudes towards learning and social skills.

In [3] Kolawole presents the results of the research he has conducted, competitive versus cooperative learning. He analyzed both strategies to find out that the cooperative learning strategy was more effective. The author settled upon the cooperative learning, because he thinks the competitive strategy generates inferior behaviors for average students and this causes them to stop trying – it scares them. The author organized an experiment: he gathered two groups of students – one to use cooperative learning, and the other one competitive learning. He then computed the means of their grades and discovered that the pupils who tried out the cooperative strategy were the ones with the highest grades.

However, comparing the grades of both groups (using cooperative and competitive learning) is not sufficient. It is very possible that some students hide in such mixed teams (probably most of the children want the best colleagues as their teammates) because they are afraid to face their lack of knowledge regarding the specific subject. Therefore, if the teacher were to use the cooperative teaching strategy, it would be highly likely for his students to obtain high grades during team tasks or assignments, but low ones when given individual tasks and tests.

It is rather natural to see that some students are not as well prepared as others may be and the only way to balance the situation, as a teacher, is to give individual tests and tasks.

Furthermore, in a university, there are three types of collaborative learning according to [4]. These are as follows:

- 1) Informal learning groups – which are formed during a class session in order to verify that students have comprehended the material presented to them
- 2) Formal learning groups – are created in order to complete a certain task (perform a lab experiment, write a report, complete a project etc.) and they can last more than a single class session
- 3) Study teams – this type of group is more durable, it can last for almost a semester or the whole year. Also, the degree of how the group is appreciated is proportional with the complexity of the subject and with the number of members.

There are two major problems that need to be addressed in a university: how the groups are organized and how to make students develop their skills through collaborative learning.

Regarding the management of groups, several aspects were taken into consideration. These are:

- 1) the forming of the groups – they have to be balanced (not

too many very bright students or too many shallow pupils within a team);

- 2) clearly explaining the grading methods to the students;
- 3) teach students the pallet of skills necessary to achieve interdependence – the pupils need to understand that working together is for the best
- 4) assign the undergraduates tasks that will increase their interrelationship – present them with questions that make them improve their problem solving skills.

In addition, it is also very important to make sure that each member of the group is making progress in improving their collaborative techniques.

These theories presented in [4] can also be applied in real life, in our professional activities. To be able to achieve your career goals, you have to expand the way you cooperate with others.

Likewise, this approach has a significant influence on one's online social skills. A study about online forums was done in [5]. The authors discuss the effect of online get-togethers reflected upon students.

In this case, two models were used:

- 1) Interaction Analysis Model – describes the way knowledge is built by analyzing the phases of critical thinking
- 2) Categories of Collaborative Behavior – contributing giving, seeking input, feedback giving.

The participants were 15 Master's students who took part in a course for 14 weeks which included weekly meetings and an online forum where students were able to find materials and discuss topics regarding the material.

The topics analyzed were Unit of Analysis and Speech Act Unit. Two metrics were used: the number of views and the number of replies.

For the first topic, Unit of Analysis, 16 replies and 98 views were obtained. In addition, contributing and seeking input had the biggest percentage. This proves that sharing and comparing are essential phases in the process of understanding this topic.

The Speech Act Unit problem achieved 13 replies and 130 views. Regarding the categories, the most significant was the feedback giving which demonstrates that students show skills in building and searching for information.

The idea of an online forum is widely used nowadays because it helps reticent students express opinions without the fear that others may not agree with them. Additionally, this method of communication aids learners to better understand the theory and to gain more confidence to express their ideas.

Today, the advancements in technology have enabled for new methods of communication that do not require the participants the need to physically be in the same location at the same time in order to work together for a joint project. Several studies [14-15] analyze the benefits, advantages and flexibility of distance education through a virtual learning environment.

In conclusion, it is important to stress out that the current results of the cooperative learning strategy are measured through group grades, but this is probably not the most

significant criteria to evaluate a teaching method.

### B. Competitive approach

Competition is defined as “a social process that occurs when rewards are given to people on the basis of how their performances compare with the performances of others doing the same task and participating in the same event.” [11]

Johnson and Johnson [10] identify a close relationship between learning styles and attitudes towards learning, including motivation to learn, involvement in learning activities, attitudes towards other individuals and self-efficacy. For students, it is easier to learn when the information is presented in a way that matches their learning style.

Suitable approaches are the competitions organized within schools or among them, when students are organized in teams and are encouraged to collaborate with their group members and to compete with the other ones, in order to achieve a well-known goal.

Competition itself can take three forms - direct, indirect and cooperative. Between students, for example, a direct competition could be a straightforward contest for who gets the highest points on a certain test. An example of indirect competition between students is scholarship. Only a fixed number of scholarships are available, so even if two students are not in a direct competition against each other, they could be in an indirect competition for occupying the last available scholarship. On the other hand, indirect competition against two or more companies, appears when they cooperate in order to create a better product than they would have created on their own. The product is then sold separately by the two companies (under different brands or in a larger, different, more complex product) and thus the companies are still competing against each other.

An interesting study was conducted by Oloyede, Adebowale, and Ojo [9], who observed groups of Nigerian children while approaching different styles of teaching Mathematics in school. That is why the authors of this paper have found it rather important to mention a fragment by Plato, the Greek philosopher and mathematician:

*“Those who have a natural talent for calculation are generally quick at every other kind of knowledge; and even the dull, if they have had an arithmetical training, although they may derive no other advantage from it, always become much quicker than they would otherwise have been and anyone who has studied geometry is infinitely quicker of apprehension than one who has not.”* [13].

The above stated quote actually points out some very interesting aspects of school subjects, since the authors find this topic outstandingly true: mathematics does have a way to improve one’s brain, or the way connections are made within it. If a child is really keen on mathematics, this means that all the other subjects (not only in school, but also life situations, in general) would be much better understood by the specific pupil, since he had already learned to mentally draw patterns, by applying a rather mathematical way of thinking. This would be useful if, for instance, the child would have to go along an

unknown trajectory, say – reach from A to B, where A and B are situated in a new city, about which the child has no information. Basically, mathematics help the children better organize themselves and get straight to the point of thinking clearly in the case of unclear situations.

Another interesting aspect regarding the above stated article refers to the competitive approach, which implied each student working individually and basically fighting with his peers over a prize or other sort of achievement. According to some recent studies, the competitive approach offers great results when it comes down to practical skills, probably because one could focus better by doing the entire practical workload which makes sense, as opposite to the theoretical skills, in which situations teamwork really seems to be the best choice, since the tasks could be divided equally, each student implementing the part of the task one is more competent at. Moreover, the collaborative approach also helps improve theoretical skills when, for instance, some students have a much more clear image of the subject than their peers and, by explaining the topic to their peers, not only do the latter ones become more aware of the subject, but also the ones with greater experience test their knowledge to see if there are any blank spaces and if so, maybe talk to the other students to clarify them or just do some research on the topic.

In addition, the competitive approach is probably most necessary in the case of sports, where the competition is vital, the thought of winning a prize is really consistent and triggers the adrenaline rush.

Studies have shown that the competitive approach is the most suitable one in terms of reviewing learned material, each student “striving for a specific prize or reward” [9].

Nevertheless, research does imply that the above mentioned approach could impose a real danger to the children, posing a risk for them to suffer from depression, anxiety, fear of just facing the teachers, students or school itself. That is because only one of the pupils achieves the final goal by being the best of the classroom, school or city, thus leading the others to great disappointment which could rather diminish their motivation and just live with the situation of not being the best, never obtaining the prize, or any award at all and just change their ways of life: not only is this risky for the children’s school situation, but also for their lives, in general, by forcing them to become blasé, without courage to try new things and without any sort of confidence.

Besides the above described downsides of the discussed approach, various researchers state that competition would only lead to pupils trying to cheat, by being desperate about becoming the best and be noticed by the teachers, fighting with their parents or just be the outcast of the classroom.

As an overall conclusion, each teaching approach has its own upsides and downsides, but according to numerous studies, the competitive one is really tricky, leading to children being disappointed by themselves and lose their inner confidence, especially when the teacher does not provide the fruitful, relaxed and “thirsty for knowledge” kind of

environment the pupils really and desperately need in these days.

### C. Mixed approach

There are many opinions regarding which approach to use. Triplett [6] found that cyclists perform better when racing with or against other people, than alone. Moreover, Lam, Yim, Law and Cheung [8] indicated that competition had a positive impact on performance goals and learning motivation in the classroom. However, Deutsch [7] suggested that cooperation embodies positive interdependence whilst competition embodies a negative one and, Kolawole [3] found that overall grades are better in a cooperative group than in a competitive one.

Cooperative learning in college is shown to both prepare the student for the expectations of the professional world and to promote interpersonal relationships whilst providing an increased effort from the participant's half towards task completion. It encourages every group member to manifest, but results indicate that the ones who benefit more are those who already have a high degree of understanding the proposed assignment.

Since many positions request the individual to work in a group, it may become necessary to develop the skills needed to thrive in such an environment. A properly balanced approach combines competition and cooperation because both have positive and negative aspects.

Mixing cooperation with competition is a tough notion to grasp because the approached positions are almost antagonistic, but, as Johnson and Johnson [10] state, it is nonetheless one that needs to be implemented. Promising great outcomes, the findings do nothing but approve the hypothesis.

Also referred to as "blended learning" [12], while it technically borrows the advantages of both competitive and collaborative approaches, it still depends on other, more important factors, like the learning attitudes of students: students who adopt wrong attitudes towards learning, or those who have low levels of motivation, usually avoid making any kind of effort to seek for effective learning strategies. A solution could also be found in the teachers' techniques: trying to increase the education of learning objectives and providing tasks to students, designed to help them build a positive attitude towards learning. If students do not understand those objectives, their learning potential is difficult to unleash. Teachers are also responsible for the online interaction with students, since technology is closer to the heart of the young generation, building and maintaining a good atmosphere in the online community has been shown to greatly improve motivation. Scholars should take to themselves the responsibility to be the masters, creators and coordinators of their learning objectives. Believing in their own abilities, students themselves will become able to choose the learning technique which best suits them.

## III. OUR TESTS OF THE APPROACHES

This chapter is based on what we have experienced in one

of our university classes. During the past six years, at the Software Project Management (SPM) Course, we selected and tested different teaching approaches for the project. The results, along with feedback from students, are kept from year to year to determine which method was best suited for which project and to find in what way they should be improved.

The other approaches that were specifically studied were on small groups of students, over short periods of time. This can lead to inconclusive results. The current study was conducted on a large number (~500) and variety of students over a long period of time (6 years).

Firstly we started with a common competitive approach and a collaborative approach, and after learning from both approaches, we tried to develop a mixture that included elements from both approaches.

### A. Basic Competitive Approach

We tested this approach with an engaging Formula 1 simulator. For each round, every team had to align 2 vehicle AIs. Collisions were possible only with the edges of the circuit, situations in which time penalties were applied.

Four milestones were imposed:

- 1) Writing the project specifications
- 2) Creating the viewer – the graphics (loading the maps, position updating, vehicles, the map, details – HUD)
- 3) Implementing the server – the physics (imposes restrictions, links the AI to the viewer, initiates connections)
- 4) Developing the final AI (the algorithm) and competing

After each milestone, a winner would be declared. The rest of the teams (the losers) had to pick up where the winners left (they received the winner's code and continued development on it). In an ideal situation, where milestones are separated by larger periods of time, everybody codes perfectly (with no bugs) and all the teams are equally formed, the previous mentioned strategy would fit much better.

The two teams with the biggest scores were rewarded with the highest exam grade (they did not need to attend the exam any more). Consequently, each team became much more motivated, hence the interviewed student's testimony, which relates that the supreme motivation factor is the final grade.

However, in the end, none of the teams managed to provide a quality server.

### B. Basic Collaborative Approach

The project used for the Collaborative Approach was an automated system that is able to analyze and extract information from documents. This system was formed by several modules: digital image enhancing, image segmenting, entity ranking and optical character recognition.

The students formed teams of five or seven and each had to build one of the five components (Preprocessing, Binarization, Layout, Paging, OCR, Hierarchy and PDF-Exporter) that were later integrated as one single project.

The final grade was calculated using a formula that depended on two other partial grades, as follows:

- 1) An individual grade - given by the teaching assistant which

valued 40% of the total

2) A project grade – which reflected the state of the project

The performance of this approach can be measured by analyzing different aspects.

One of them is the number of students that formed a team. Although the groups were cross-functional, the members complained they obtained small grades due to the fact that they were too many. This led to a crowded team-atmosphere and a big chance for the lazier students to obtain good grades on behalf of others. The fact that some students took advantage of others affected also the correctness of the approach and the organization of the course.

Furthermore, the mode in which the team was formed was self-organization. This meant that each member could implement which task he/she wanted. The downside is that this method could cause chaos and could have a bad impact on the results.

An essential part of this approach is having a sort of reward that will be granted for the work finished in due time by the individuals. This will make the students work harder in order to complete the assignments on time. But we have to take into account that people should not involve more in finishing a job because of the rewards that awaits them, but also because they enjoy their choice of work.

In conclusion, the Collaborative Learning is an essential part in having a successful career, in improving communicational and educational skills.

### C. Mixed approach

Learning from the two approaches, in the academic year 2013-2014 we developed a project that included elements from both strategies. The project specification itself needs to reinforce the rules in order for this strategy to work.

The project consisted in a voting based image binarization system, using a mixed competitive-collaborative approach. The project purpose was the development of an “Image Binarization System” (IBS), which consisted in two components:

- 1) Binarization Algorithm Module (BAM) – an executable which produces an output binary image from a continuous-tone image.
- 2) Voting Binarization Algorithm Module (VBAM) – that makes a binary image from independent BAM results.

The main purpose of the project was to create a good binarization result, but as binarization proves to be a very subjective processing, more approaches will be used. These are the BAM modules. The VBAM then creates a merge between these subjective approaches into a final result that the majority agrees with.

The students from each laboratory class were divided in teams of around 3 members, so that there were 4 teams per class. The work was divided as follows:

- 1) Three teams worked on BAMs – each team developed a BAM;
- 2) One team developed the VBAM, based on the three BAMs mentioned, and it is responsible of the synchronization

between teams.

Rather than the previous approaches, the proposed solution tries a balance between the collaborative and competitive aspects. There were around 70 students involved in the project. They were split in 5 groups (each having the laboratory at a different time) and each group was again split in 4 equal cells. One of the cells was special, as it generated a merge between the results offered by the other three cells. Thus it needed to minimally organize the three BAM cells and needed a bit more information in order to understand how the individual algorithms worked, in order to offer the best VBAM result. Thus, the forth team was also responsible for the project management of the three BAM teams.

The evaluation was mostly objective, obtained by an automatic verifier that measured the performance of the VBAM voting results, as a per-team grade, and the BAM results as individual grade. The performance was measured by feeding the binarization result to the Tesseract OCR engine and considering the amount of correctly-recognized text.

A very interesting fact that resembles with the collaborative competitive hybrid approach is the grading system in which the students were evaluated in various ways. It valued the collaborative approach more than the individual one unlike in the previous project.

All the BAM teams from all the groups competed against each other and the VBAM teams likewise. Another evaluation was made at a group level using the VBAM results. Using those scores mentioned a number of top BAM teams were selected along with the best VBAM team in order to be reassembled as a new team that could provide the best IBS system implementation.

The greater team size had the advantage of having more design opinions from which a better algorithm could have emerged, but required more coordination. The sub-teams implemented the algorithm and tested after the strategies in order to determine the cases in which those succeeded or not. Finally the team strategy combined a common set of advantages that were agreed upon. Regarding the organizational aspects before the project started, each formed team had to make a portfolio with the team members CVs and attributions.

The project grading ratio consisted as follows: 3/5 of the project team result and 2/5 of the individual contribution on the algorithm.

For a bonus, the students were able to work at the end of the semester to fine-tune the wining VBAM to work with the top N BAMs.

## IV. RESULTS AND CONCLUSIONS

All learning approaches described within this article may prove both beneficial and disadvantageous from a certain point of view depending on the context of their employment [16].

Results for the competitive approach proved not to be pleasant for the students. For this, they also blamed the organizational aspects:

- 1) Too many students/team thus a good coordination among them was very difficult, if not nearly impossible to achieve.
- 2) Each milestone imposed a winner and then, all the other teams had to carry on the implementation starting from that point
- 3) The code received after each milestone was buggy and not well tested, thus leading to buggy applications. As a result, all the teams (except the one which won the respective milestone) needed to do extra work in order to understand and debug the code.

The feedback offered by the students show that correctness was the biggest issue. There were students who worked very hard and others that were not so interested. Because of the interchange of code, the latter also got good grades.

Likewise, the satisfaction was very small, mostly because the resulting application was not functional and many felt that they did not learn anything.

However, the competitive learning method was the one to inspire students the most. They would try much harder to give their best and develop the most complex and correct products, since they had a clear indicator of performance: the comparison with other students. The competitive approach shows great potential; unfortunately, it was dragged down by those issues.

Alone, the collaborative method does not appeal as much to the pupils: most of the time, they would put in as little effort as possible, since they do not feel the need to improve their module at their best because the final result does not necessarily reveal each component's importance.

The grading method also seems weak in the collaborative method - all students got high grades - that is why no one complained about this issue.

Thus, the collaborative scheme seemed to the students like another school project that has to be completed and didn't offer enough interest.

Due to a better organized environment, the only approach which managed better results along the years was the mixed one. Therefore, most of the bad points mentioned earlier were not present in this case.

One benefit of the competitive-collaborative approach is that the failure of a team in the final functionality does not produce the failure of the entire project, a scenario very likely for a large project built on a collaboration basis.

Also, in the competitive-collaborative approach, it is easier to synchronize the teams, since one team was responsible with the management and the actual teams are relatively small and separated. Failing to synchronize in a collaborative medium can lead to delays from other members waiting for modules with which to test.

The grading is also fairer than the competitive and doesn't include the disadvantages of collaborative. However, in both the collaborative and mixed approaches the grading contains some subjectivity because of the different types of modules, but the mixed approach has some advantages. Both the

approaches' results are similar; the competitive approach generating slightly higher overall grades, but this is not necessary a good thing, as students can hide on the work of their teammates. This can be confirmed by the fact that during the individual management approach the grades were also lower. Considering this, the mixed approach may be fairer.

In case of competitive approach, the results of the students were the weakest. Although the result is a quality product, there comes a frustration because of losing the competition, possibly due to the non-homogeneous structure of the team.

Therefore, the competitive-collaborative approach provides a better environment and student interaction for project management and also a balanced fairness score.

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