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Clustered Social Representation of Active Methodologies in Engineering Courses: A Case Study at Goiás State, Brazil

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Abstract

This work aims to identify changes and trends that favor the students' learning style and autonomy, through a qualitative evaluation of the social representation of students in the development of individual and group activities. Questionnaire application and interviews were carried out at both the Pontifícia Universidade Católica de Goiás (PUC Goiás) and the Universidade Federal de Goiás (UFG). The questionnaire is based on a 7-point Likert scale, which evaluates 13 items in four dimensions. After answering, each item is analyzed by the k-means clustering method, which groups the data unsupervised according to the levels of similarity of each item. With the result, we can point out what are the aspects that determine the skills and psychosocial profile of students, from this, it will be possible to make changes in the methodology applied to benefit the learning process of students, favoring multidisciplinary skills, the courage to face the students, challenges creatively, the ease of adapting to change, working as a team, valuing and understanding one's point of view with commitment and ethics.

Keywords: Collaborative Work, Teaching and Learning Assessment, Engineering Education, Active Methodologies, Problem Based Learning.

1. Introduction

Modern society is in a continuous process of transformation, fueled by technological advances that dictate an ever-faster pace, a way to meet the unpredictable and changing needs in training; it is the search for new teaching methodologies that focus on the students' role. Ribeiro[1] states that society is in a continuous process of transformation, fueled by technological advances that dictate an increasingly fast pace. In this context, Engineering Education is affected by demanding knowledge of immediate applications. And the most noticeable effects of this are the increased volume of knowledge required and its rapid obsolescence.

What's more, the activity of the Engineer has expanded greatly since its inception, providing the specialist with work in different areas during his professional life. Such factors end up requiring students skills and attributes, different from the technical knowledge acquired during graduation. These were even the reasons that made UFG and PUC Goiás to rethink their traditional teaching and learning model.

Moreover, for Davidson[2], due to the development of research on learning and education published in the last decades, new visions have started to emerge, such as cognitive and social perspectives, different from the traditional behaviorist view that uses punitive and reinforcing methods. At this time, many educators have stopped using conventional methodologies, such as the traditional short "question-answer" for the class. This process in which students just listen, repeat and sometimes apply knowledge to an approach that is no longer focused on the teacher. Thus, students take an active role in the learning process. And as Camas[3] enforces: *"a content memorization approach education should be reconsidered towards the use of scientific knowledge for solving problems, being notorious that just memorizing data content, nothing will be achieved".*

From this new conception, UFG and PUC Goiás began, in 2007 and 2010, respectively, to introduce active methodologies in the Engineering disciplines, to better prepare students' for the challenges and demands encountered in both the school environment and the workplace. social environment, encompassing general aspects of coexistence and collaboration. Based on this principle, the two institutions promoted a qualitative assessment of students' social representation in order to raise perceptions of the development of individual and group activities. The study was conducted in the second half of 2017 through forms and interviews.

From the assessment results, it is expected to identify changes and trends that favor students' learning style and autonomy. And more, it seeks to promote the reflective, critical and scientific thinking of Engineering students, forming solidary and cooperative citizens, as well as competent professionals, capable of creatively facing the challenges of the profession. Other broader objectives of the study are to foster the development of a society that can reap the fruit of better prepared professionals through a paradigm shift in the teaching and learning process.

A new way to meet the unpredictable and changing needs in student education is the search for new teaching methodologies that focus on their protagonism, favoring their motivation and autonomy[4]. For Berbel[5], active methodologies gradually contribute to the development of scientific spirit, critical and reflective thinking (ceasing to be the student, mere recipient of information and knowledge); ethical values, among other achievements of the same nature. These methodologies also contribute to form autonomous, critical, participative engineering students, involved in social issues, protagonists of a process of identification and resolution of everyday problems[6].

According to Miao[7], Problem-based Learning (PBL) is a philosophical view of social constructivism, which uses small groups and real problems found in everyday life. In this way, the student will develop skills, commitment and ability to adapt to change, solve problems, develop critical thinking, work in groups, value and understand peoples point of view.

In this sense, the student will no longer analyses the problems in isolation and without contextualization, as often happens in traditional education. The result of content deposited on students without any connection with everyday difficulties, as exposed by Vygotsky[8] as he states: *"The student who uses this method to investigate any property of water - for example, why water extinguishes fire - will be surprised to find that hydrogen burns and oxygen fuels fire. These findings will not be of much use to you in solving problems"*. Vygotsky[8] also argues that group tasks offer several advantages, which cannot be acquired in individualized learning environments.

Odelius[9] states that the academic career also demands a collaborative profile. Thus, the most important capabilities for research groups are openness to human diversity, social skills, personal, relational and behavioral skills, cooperation and responsibility.

According to Damiani[10], cooperation is centered on mutual work between individuals. And, generally, it is not the result of group negotiation, enabling inequality in the performance of tasks and hierarchies among students. Quite unlike collaboration, in cooperative action team members work to solve problems together for a common goal; decided by the collective, thus creating bonds that do not tend to be hierarchical, with shared leadership, mutual trust and co-responsibility.

2. Design/Method

This study is a quantitative assessment of students' social representation, based on the application of questionnaires and interviews in three different subjects, in which students were exposed to the active methodology, PBL. Taught at UFG, the first course is optional for all Engineering courses. It has the characteristic of being a management-oriented subject, with numerous concepts and theories. And it generally involves little calculation and demands the use of tools and software, which help in the organization and structuring of a project. The other two subjects were applied at PUC Goiás. One of them is "Systems Project Management", from the eighth period of the Computer Engineering course. The article with characteristics like UFG's "Project Management" focuses on systems development. The other subject is "Data Communication", applied in the last period of the Electrical Engineering course. Complex, the matter, with concepts inserted in other periods, has a dense mathematical part, which requires the use of computational tools for simulation and problem solving. It is still a discipline that can influence the student in the completion of the Course Conclusion Work (CBW), as both occur simultaneously in this final stretch of the undergraduate.

The active PBL methodology was then applied similarly to these three disciplines, with part time focusing on group activities and one on individual actions. Evaluations were made in two ways: one weekly, based on the resolution of real problems, involving topics contained in the course menu; and another performed online, twice a semester, based on the resolution of problems solved by the students themselves, in an objective and multiple choice.

In the most important weekly assessments, students received a sheet, with information on the thematic axis, module and level of complexity of the problem. Some terms related to the topic were inserted, as well as a real problem faced by managing Engineers or the academic community. The teacher commented on some key words or thematic subjects, which could cause some doubt. Students, in turn, should solve the problems and bring them

to class discussion in the next class. After this moment, if any doubt arose on the part of the student about the subject, the teacher sought to answer his questions.

Before starting any activity, the teacher tried to guide his students on the objectives of the PBL method. Well, the vast majority were having contact with the methodology for the first time. Hence the doubts arose. To instruct them in solving problems, the student was then instructed to perform the following steps:

1. Identify and understand unfamiliar terms;
2. Identify the theme surrounding the problem;
3. Raise the requirements and knowledge necessary to try to solve the problem;
4. Describe the didactic objective as well as what it will learn if it engages in the problem-solving process; and
5. Finally, find solutions to solve the problem or describe why the problem cannot be solved.

Therefore, following the guidelines suggested by the teacher, the student would be able to start the activities, trying as best as possible to solve the problems, much of which is difficult to solve. For this, the student demanded knowledge of technical terms, hitherto unknown, as a way of setting the student about the issues that involve the problem, without leaving it explicit.

Finally, it is worth stressing that the objective of the problems was not focused on the outcome, but on the process, which is directly linked to learning skills, resulting from activities performed in the group and individual work phase.

A Likert scale, according to Costa[11], is a model used to measure attitudes in the context of behavioural sciences, and he also states that *"likert's scale of verification consists of taking a construct and developing a set of statements related to its definition, to which respondents will give their degree of agreement"*.

A questionnaire based on the Likert scale was used to evaluate 13 items of four dimensions, as shown in Table 2:

Table 1. Dimensions assessed on the Likert scale.

Dimensions	
Team work	Learning
Multidisciplinary Aspect	Leadership

Thirteen statements on a 7-point Likert scale were chosen for the questionnaire, as shown in Table 2, and were applied to students in all three subjects, immediately after the close of the semester, and made available online and without student identification.

The questionnaire was answered by 30 students, optionally and without any identification. The intention is to survey the 13 items, using clustering methods that allow the data to be grouped according to the level of correspondence.

For data analysis we will use the k-means clustering method. According to Wagstaff[12], it is an unsupervised technique for data analysis; which groups data according to similarity levels, and the algorithm has access only to the set and no other information is given.

Thus, clusters will be generated from the data extracted from the questionnaire, in order to structure and facilitate the identification of trends and connections in the students' learning profile. The process can generate numerous clusters with different levels of similarity, performed in order to identify their ideal quantity, to analyze the learning profile of students exposed to the method.

Table 2. Applied Questionnaire.

Question	Affirmations	1 - Point	7 - Points
1	Which role did you develop most during PBL executions (albeit informally)?	Collaboration	Leadership
2	How much do you perceive the PBL method as "DYNAMIC"?	Nothing dynamic	Essentially dynamic
3	How much does the PBL method stimulate you in the "KNOWLEDGE SEARCH"?	I didn't need to look for knowledge	Fully knowledge-based
4	Did you learn more from the PBL method in "WORKING INDIVIDUALLY" or "WORKING IN GROUP"?	I learned a lot more by working individually	I learned a lot more working in a group
5	How much did the PBL method require you to "TAKE ROLES" within your group?	I was passive. I just solved the questions that came to me	Exercised leadership and cooperation in the group.
6	How much did the PBL method induce you to pursue "SELF-LEARNING"?	I depended on peer and teacher explanations	I was completely self-taught
7	How much did the PBL method expose you to "RELATIONSHIP PROBLEMS" in the group?	I tried not to get involved with the group	I totally joined the group
8	Did the PBL method require you to experiment with "MULTIDISCIPLINARITY" to solve problems?	I used only the concepts of the discipline	The problems depended entirely on concepts from other disciplines.
9	Do you consider that this learning method should be applied in your course?	Should not be applied to any discipline	Must apply to all course subjects
10	How much does the method achieve the educational objectives (fulfilment of all syllabus)?	It deviates completely from the discipline menu	Fully covers content with equal emphasis for each topic
11	Do you believe this learning method applies more to what kind of discipline?	More to the theoretical subjects	More to the applied disciplines.
12	How decisive is the teacher's lecture in solving problems?	We can solve absolutely everything alone	Without a lecture you can't solve anything
13	How much does the result of the PBL assessment performed correspond to your learning of the course content?	The results of the assessments totally underestimate my learning in the subject.	Assessment results Totally OVEREST my learning in the subject

2.1. Results and Discussion

From the answers obtained in the questionnaire, several processes were performed to identify the ideal number of clusters that presented a significant level of difference. This would make it faster and easier to understand the learning profile of the students. The process with only two clusters presented satisfactory results, divided as follows: one cluster with 14 students, another with 16 students (Table 3). It is noteworthy that the statements contained in the table refer to the questionnaire applied.

Table 3. Clustering Process Outcome.

Question	Cluster 1-14 Students	Cluster 2-16 Students	Difference Between Clusters
1	4.00	5.62	1.62
2	5.64	6.06	0.42
3	4.93	5.88	0.95
4	2.60	5.60	2.92
5	5.79	5.81	0.03
6	5.43	6.00	0.57
7	3.29	6.06	2.78
8	4.00	5.56	1.56
9	4.57	5.31	0.74
10	4.50	5.38	0.88
11	4.93	4.94	0.01
12	5.00	5.69	0.69
13	4.86	5.56	0.71

From Table 1 it is possible to identify that there are correspondences between clusters. Questions 2, 5, 6, 9, 11, 12, and 13 have little or no difference between them. Questions 1, 3, 4, 7, 8 and 10 present significant levels of inequality between clusters. Thus, we can identify which are the aspects that define the psychosocial profile of students and whether there are factors that determine their skills acquired in the subjects.

By analyzing questions 1, 3, and 4, we make sure that students in cluster 2 can be defined by developing more leadership roles, learning more from group work, and seeking more knowledge to solve activities. Quite unlike students in cluster 1, who prefer to perform collaborative tasks, they learn more by working individually and are not seeking as much knowledge to solve problems.

What is striking now is the result of question 7: the students who learned the most from working in groups were also the most exposed to relationship problems. This may be because group work activities could be divided among the members, precisely because they presented more than o ne problem and unknown terms. Thus, activities became more focused on cooperation than collaboration, generating hierarchies and inequality in the division of tasks. Thus, resulting in relationship problems between the members of the group.

However, what may explain the reduction in problem exposure by students in cluster 1 is that they are more used to doing all the work individually, and not waiting for the division of tasks. Students in cluster 2 expect to divide tasks equally in the group. As cooperation favors the emergence of inequalities and hierarchies, these students often have more relationship problems.

However, question 8 points out that cluster 2 experienced more multidisciplinarity in problem solving. This trend may have arisen due to the higher frequency of relationship problems faced by cluster 2. This eventually required social and interpersonal skills to deal

with the division of tasks within the group. Finally, the last question with well-defined unequal characteristics was question 10. In this item it is interesting to note that students in cluster 1 believe that the method deviates from the course menu and does not achieve the programmed educational objectives. They believe the story did not completely comply with the proposed content. Thus, the teacher/advisor can use the PBL to charge the student more activities in the phase of individual work, with slightly more dense problems. We can state, then, that the student at this stage will be more motivated and thirstier for the search for knowledge, compared to the activities performed in groups, that the approached methodology fulfills the syllabus well.

Questions 5 and 11 did not show any significant difference between clusters. Thus, such aspects may be global to the methodology. We understand, therefore, that any student who is immersed in the problem-based learning process can be encouraged to develop such skills. Question 5 indicates that taking on roles within the group is a recurring aspect of any psychosocial profile, whether of a student with more intimate characteristics and who prefers to cooperate or collaborate; whether from a student with a leadership profile. Question 11, in judging that the methodology can be used for both practical and theoretical disciplines, already tends to find that the method applies more to practical disciplines.

Finally, questions 2, 6, 9, 12 and 13 have a slight difference between clusters, but it is insufficient to define a specific learning profile for each cluster. Thus, such questions will be analyzed exclusively by the average score of all students shown in Table 4.

Table 4 - Result of the average score among all students.

Question	Cluster 1-14 Students	Cluster 2-16 Students	Average among all Students
2	5.60	6.10	5.87
6	5.4	6.00	5.73
9	4.60	5.30	4.97
12	5.00	5.70	5.37
13	4.90	5.60	5.23

Based on the questions above we can then define the behavior of the students with respect to each dimension present in Table 3 but without correspondence between clusters or students. At this point we are analyzing the data from the calculated average by summing the values of the grade set of all students. Hence, we divide by the number of students in the set. Table 5 shows the students' behavioral profile based on their grade point average and their interaction with the PBL.

Table 5 - Students' psychosocial profile for the questions in Table 4.

Question	Profile
2	They tend to be essentially dynamic.
6	They tend to be self-taught.
9	They believe it should be applied to more than half of the course.
12	Without a lecture you can't solve much.
13	The results of the assessments overestimate the learning of most students.

As for Table 5, it is important to highlight some points. One is the tendency of the method to encourage students to be self-taught in carrying out the activities proposed by PBL (as Question 6, as opposed to Question 12). From this we can analyze to what extent the participation and guidance of the teacher in the classroom, applying the PBL, can influence the self-learning process by the student. We therefore believe that the whole process that involves student problem solving can be influenced by the degree of teacher

participation. Both at UFG and PUC Goiás, the subjects taught by teachers still follow the traditional teaching model. But gradually, they are being replaced by philosophical views of social constructivism, which aim at student protagonism, through active teaching methodologies. A research finding: Approved by students (Question 9 in Box 3), the problem-based teaching methodology should be applied to more than half of the Engineering courses of both institutions.

4. Conclusion

The application of questionnaires allowed us to evaluate students' psychosocial representation in four dimensions: teamwork, multidisciplinary aspect, learning and leadership. Thus, from the collected data, it will be possible to make changes in the methodology applied to benefit the learning process of students. And one of the important transformations will be to rethink academic activities in order to make the division of tasks more focused on collaboration, thus reducing the hierarchies and inequalities of this process, as well as relationship problems. We even believe that with this methodology, even students from cluster 1 who prefer to work individually and do not believe that the proposed disciplinary content has been achieved can benefit by increasing the number of problems in the individual work phase by addressing more content, precisely because they are more motivated and willing to learn at this stage.

Finally, the publication of this qualitative research will serve as a kind of guide to point out the necessary changes that favor the students' learning style over the years. Approach that has already delivered its positive results by providing the fostering of multidisciplinary skills, the courage to face challenges creatively, the ease of adapting to change, working as a team, valuing and understanding one's point of view, with commitment and ethics.

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