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The Effects of Applying Assessment FOR and AS Learning in Theoretical Engineering Courses*

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The paper presents research conducted with college students (N = 85) studying for their bachelor's degree in engineering. The study followed the teaching of two theoretical engineering courses, which were previously taught in a teacher-centered paradigm where the assessment of the students was based on Assessment of Learning. The goal was to enrich the assessment practices and to examine whether Assessment for, and as Learning will increase students' achievement and motivation. Instead of using a final exam as the main tool for students' assessment, we integrated Assessment for, and as Learning during their studies. We included significant and challenging tasks to be carried out in diverse learning environments, such as Learning from Mistakes approach, Project Oriented approach, and Collaborative Learning. The results were positive. We present the students' achievement compared to previous years, together with the students' opinions about the applied assessments. We summarize with several suggestions for educators about the integration of different means of assessments during the teaching process.

Keywords: assessment for, and as learning; engineering education; learning environments

1. Introduction

Assessment is an essential component of the teaching and learning process. While teaching methods tend to be updated frequently, the implementation of new innovative assessment tools is much slower [1]. Assessment is probably the most important thing we can do to help our students learn [2]. Hence, it is in the educators' best interest to ensure that the assessment practices they use don't hinder learning, but rather help it.

Students attach great importance to the evaluation process. It is well-known that the evaluation method influences their motivation for learning [3]. It dictates what, how, and how much they learn [4, 5].

There are different approaches in achievement evaluation: (A) The qualitative approach, according to which the assessment is perceived as an Assessment for Learning (AfL), also known as formative assessment. (B) The quantitative approach, according to which the assessment is perceived as an Assessment of Learning (AoL), also known as summary assessment [6]. (C) The diagnostic approach, according to which the assessment is perceived as Assessment as Learning (AaL) [7]. According to some authors, the notion of AaL is an aspect of AfL (e.g., [8]).

Each of these assessment approaches sets different goals that influence and direct the learning and teaching culture in the classroom. The objectives of the assessment according to the AfL approach are to provide detailed feedback to promote learning and teaching. This is usually done during the learning process. The goals of the evaluation according to the AoL approach are a summary or report on the level of achievement of the students, in the form of a grade, for classification, certification, and selection purposes, typically at the end of the task or course at hand. The goals of the evaluation according to the AaL approach are to use assessment as a process for developing and supporting students' metacognition abilities [9]. Traditionally, the focus of classroom assessment in higher education institutions has been on AoL, with an exam given at the end of the course [6]. The exam is a central and exclusive component in determining the student's final grade in most courses, especially in theoretical courses. The assessment approach is crucial in the learning process. If we want to enhance students' learning, the role of AfL and AaL should receive much greater attention than AoL [7].

Among educators there is a common assumption that the compatibility of teaching, learning, and evaluation is essential for achieving the goals of education in all its frameworks [10]. Indeed, those three components, which have dominated the institutions of higher education for decades, have proven themselves to be effective in attaining the goals of higher education, as defined in the past.

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Questions about the relevance of academic institutions for the labor market, and the rapid changes that apply to it, have been raised in recent years [11]. Meeting twenty-first century education objectives requires changes in teaching and assessment, moving from assessment as a measurement to diagnosing learning in order to improve it [12]. Any student who studies at an institution of higher education, including every engineering student, will be forced to deal with professional knowledge that is constantly renewed.

The paper presents enrichment of student evaluation methods in two theoretical engineering courses, with two different populations. In the next section we present background on assessment practices. Then we discuss the learning environments that were used. We include the research description, focusing on the changes made in the courses to implement the AfL and AaL approaches and the outcomes of using them. We summarize by presenting some implications for educator' assessments, according to the students' achievements and their overall feedback given at the end of the semester.

2. The assessment methods

The evaluation of students in an academic course has two main goals: to design learning and teaching during the course (AfL and AaL), and to summarize the students' achievements at the end of the course (AoL). Assessment of learners in higher education institutions is often characterized by students' dissatisfaction with the methods of evaluation in the courses. Various studies have found that a large number of students are not satisfied with the quality of the evaluation [13]. Most of the students' claims related to the evaluation are to the fairness of the assessment in the context of matching the exam questions with the content and the type of questions to which they were exposed during the course. All the assessment methods are important and have a different effect on the learning and teaching process. So, it is important to make a much stronger investment in AfL and AaL in those processes.

AfL is defined as "part of everyday practice by students, teachers and peers that seeks, reflects upon and responds to information from dialogue, demonstration and observation in ways that enhance ongoing learning" [14]. AfL focuses on learning, not on grades, and aims to reveal students' understanding and, if needed, correcting it while learning takes place [12]. The goal of AfL is to advance learning [15] by accomplishing tasks that will enable learners to advance their understanding during learning, allowing the teacher to navigate instruction accordingly. Students understand what they are to learn, what is expected of them, and are given feedback on how to improve their work. AfL can be used by teachers to motivate their students and enhance their level of commitment to learning. Using AfL shifts the students' point of view to focus on learning rather than grades, and changes the classroom dynamic to one of student success.

AaL is a process of developing and supporting metacognition for students [7]. The students critically connect between their assessment and their learning. They are active, and apply critical thinking to make sense of information and to relate it to their prior knowledge. This is a constructivist metacognitive process where students construct new knowledge. Students personally monitor what they are learning and use the feedback to make adjustments, adaptations, and major changes in what they understand.

In terms of class practices, activities that evoke AaL and AfL involve different pedagogical aspects such as student-teacher interaction, self-reflection, motivation, and planning of learning environments [16]. The support of teachers in these types of processes enables students to reach the next stage in their learning process. In this method, students are responsible for their knowledge and do not lean only on the teacher's feedback [17]. Both AfL and AaL incorporate self-assessment or peer-assessment for students to actively check and evaluate their own knowledge and understanding.

3. The learning environments

A multi-verse of teaching approaches is adopted around the world, for both students and professionals [18]. The different approaches are geared towards helping students understand concepts and development processes [19], identify the relevance of course content and thus develop intrinsic motivation [20], and more. We present some learning environments that we used in our teaching process.

3.1 Project oriented approach

The Project Oriented (PO) approach is an active learning approach, like Problem Based Learning, Project Based Learning, and Discovery Learning [21]. The main characteristic of the approach is that it accompanies the learner in implementing an applied project in addition to learning theoretical materials. The approach fosters the creativity and application of the material learned through various projects. The projects are the result of the creativity of the lecturers and collaborations with industrialists and companies in the economy. Many of the projects are for the needs of the community.

The unique format of the course is based on the assumption that self-practice will enrich the students' knowledge and motivation. Traditional class is replaced by a modern approach of self-learning in the methods and times the students prefer [22]. Chassidim et al. [23] found that using PO in the software-engineering obligatory course promoted the special needs of software engineers, especially the soft-skills, effectiveness of the team-work, and the overall development process of the project.

Assessment in the PO approach is challenging. Students did not consider being evaluated on a work product to be a fair assessment of learning compared with a traditional test [24]. Assessment of PO needs to focus on the objectives that PO fosters in conjunction with the educational course objectives. The assessment of the end project is certainly important, but it is also important to focus on assessments of each of the project stages, which enables the meaningful learning that happens throughout the project [25].

3.2 Learning from mistakes approach

Errors involve wrongdoing. Yet, everyone errs, and one may learn from wrong no less and perhaps even more than from right [26]. In the last two decades, mathematics and science educators attempted various ways of using errors as a means for learning (e.g., [27–29]). The studies on learning from errors involve an aspect of constructive approach, as the utilization of errors was based on students' prior knowledge, which was imprecise or vague to some extent. The goal is to refine their knowledge and skills by raising conflict, or cognitive dissonance, in using errors.

There is growing consensus that students can learn effectively from errors. However, textbooks don't often include incorrect examples, and creating materials and lessons that include incorrect examples can be very time consuming for teachers [30]. Error reflection is beneficial to learning. For example, having students think about and correct their own errors can lead to greater engagement and improved problem-solving skill [31, 32]; studying the errors made by others may be even more effective [29], in part because it exposes students to multiple perspectives other than their own [33].

Being wrong is an integral part of the assessment process, and understanding how to learn from mistakes and misconceptions helps educators and students get the most from their learning experience [34]. The error is (sometimes) an essential part of effective learning and it can be used by teachers to motivate students.

3.3 Collaborative learning

Collaborative learning is a broad notion used in many disciplines [35]. In general, it means a group learning something together. A group can be two or more people, sometimes it can even be an entire class or a community of people. The time frame in which the learning can happen is also not defined and can range from one hour to a year or more. The learning can be interpreted as studying new material in a course; however, it can also be interpreted as solving a problem, or conducting any learning task. In this scenario the learning is a side-effect of conducting the task or solving the problem.

The motivation for this approach is that the different nature and knowledge of each participant contributes to the learning process. The groups can be chosen by an outside source (for example the lecturer) or by the participants of the learning process. The groups can be homogeneous or heterogeneous, for example the different individuals in the group can have different roles.

The assessment of collaborative learning is not a simple task [36]. This is due to the fact that assessment usually relies on the product developed from the learning process. Yet, it is hard to evaluate how much each participant contributed to this product.

4. Research description

4.1 Research rationale and questions

The rationale for the research was to use different assessment approaches with the different learning environments with the objective to get answers to the following research questions:

- How can we use AaL and AfL in different learning environments for theoretical engineering courses?
- Does adding AaL and AfL to the assessment process improve the students' perceived accuracy of their assessment?
- Does applying different assessment approaches have advantages over using the traditional AoL method only, in theoretical engineering courses?

4.2 Research population

The research was conducted on two different populations of students studying for an undergraduate degree in engineering: a group of 35 students studying in the Department of Industrial Engineering and Management (IEM) and a group of 50 students studying in the Department of Software Engineering (SE). The courses that were chosen are the Analysis and Design of Software/Information Systems, which was taught to both student populations (85 students) and the Algorithms course, which was only taught to the SE population (50 students).

4.3 Algorithms course—tools and methods

The course is part of the theoretical discipline taught in the SE Department. Students take it in the 4th semester of their eight semesters. The course on Data Structures is a prerequisite and it is a prerequisite for the Algorithms in Graphs course. The course is based on the books: Fundamentals of Algorithms [36] and Introduction to Algorithms [37].

4.3.1 The course structure

The course contains four parts:

1. A thorough introduction to asymptotics—Asymptotic notations are a way to define order between functions and are used to describe running time complexity of algorithms.
2. Complex data structures—The two main data structures described in this part are: (i) Binomial Heaps (ii) Disjoint Set Structure.
3. Greedy algorithms—This is an algorithmic technique, mainly applied to optimization problems, in which decisions are taken only on the basis of local information. A general characteristic of the technique is shown with several examples.
4. Dynamic Algorithms—This is an algorithmic technique, mainly applied to optimization problems, in which the problem is solved via solving smaller sub-problems. The stages of the technique are taught, and several examples are shown.

The course is taught via a teacher-centered paradigm. The learning outcome of the course is that on successful completion of the course, the students will be able to:

1. Define the different asymptotic notations.
2. Prove a function belongs to some asymptotic notation.
3. Prove that two sets, defined by asymptotic notations, are equal.
4. Describe the operations of the data structures taught.
5. Describe proofs taught in class.
6. Describe algorithms taught in class.
7. Develop a greedy algorithm for a new problem.
8. Develop a dynamic algorithm for a new problem.
9. Choose the algorithmic technique best suited for a problem.

4.3.2 The change in the evaluation process

Until this semester the students were evaluated only by an exam and homework. The exam took 3 hours and checked the abilities of the students in goals 1–6. However, the exam did not check if goals 7–9 were fulfilled. This is due to the fact that the process of developing an algorithm to an interesting problem is time consuming; hence, a student cannot do it during an exam that also checks other abilities. Moreover, the process of building an algorithm demands high concentration and thinking. Thus, accomplishing this task, under the pressure of an exam, is highly unlikely.

The students were evaluated on goals 7–9 via homework, composed of several problems. The students needed to find an algorithm to solve each of them, in one of the aforementioned techniques. However, in theoretical homework students' capabilities are not always evaluated correctly since some students copy their work or find answers from external sources instead of solving the problems by themselves. Hence, evaluation only via theoretical homework is not sufficient.

Thus, in this semester another evaluation scheme was added, a collaborative learning (CL) session. It was carried out as follows: The students divided themselves to groups of three. In the last week of the semester, a special 3 hours session was conducted. At the beginning of the session each group received a problem. During the session each group needed to decide which algorithmic technique best suits their problem, design the algorithm based on the chosen technique, and prove it returns the optimal solution. Half of the groups received problems that were suited for greedy algorithms and half problems suited for dynamic algorithms. At the end of the session, each group submitted a written paper describing the algorithm and the proof.

Later that day, each group met with the lecturer and the TA to explain their work and answer questions. The grade of each student was determined both by the paper submitted and by the meeting with lecturer and the TA. The evaluation was individual and not the same for the entire group, it differed by their answers and explanations in the meeting.

4.4 Analysis and design course—tools and methods

This course is taught in two different departments. In the SE Department, it is part of the System Engineering discipline and students are obligated to study it in their 4th semester. In the IEM Department, it is part of the Information System track and students are obligated to study it in their 6th semester. The course's prerequisites are the Object Oriented Programming (OOP) course and the Information System Analysis course. The course is based on the book: Systems Analysis and Design: An Object-Oriented Approach with UML [39].

4.4.1 The course structure

The course familiarizes students with the methodologies, tools, and methods for developing a software system or information system. The course focuses on systems developed based on the OOP paradigms. System analysis and design is introduced using the UML diagrams of Use Case, Class Diagram, Activity Diagram, State Machine and Sequence Diagram. Information about those UML tools and how to build them is based on the guide: Guide to Applying the UML [40].

Until last year the course was taught via a teacher-centered paradigm. The learning outcome of the course is that on successful completion of the course, the students will be able to:

1. Describe and implement the various stages in developing information systems in an Object Oriented approach.
2. Define user functional requirements through Use Case and Activity Diagrams.
3. Design the system components using a Class Diagram.
4. Build a constraints system on Use Case and Class Diagrams using OCL tools.
5. Model functionality of a system via Sequence Diagram.
6. Describe the dynamic aspects and flows in the system using Activity Diagram and State–Charts.
7. Integrate various diagrams in order to describe and design a full system.

4.4.2 The change in the evaluation process

In previous years the student evaluation process was based primarily on an exam and 5 home tasks that were given during the semester. The exam took 3 hours and checked the abilities of the students in goals 1–6. However, the exam did not check these abilities in depth. Moreover, it was impossible to check students' ability to fulfill goal 7 under those conditions. These difficulties in assessment of students' abilities were due to time constraints. In an exam it was impossible to demand more than a basic analysis of a straightforward system.

On top of that, when designing or analyzing a system, there are several possible solutions. Some are obviously inferior to others. Yet, some emerge due to subjective beliefs about the future development process that the system will undergo. Therefore, it is difficult to design a system without fully understanding its functional requirement, needs, and future development path. In addition, it is hard to evaluate a design without understanding the subjective beliefs that led to it.

This problem is the main reason why home tasks cannot serve as a good indication or evaluation method for students' understanding and implementation level of the design process. Moreover, in home tasks all students receive the same mission to execute on the exact same system. This in turn leads to a collaborative design process, where some students fail to practice and indicate their abilities, due to copying others' solutions. Thus, this semester we decided to completely revamp the course into a PO course.

The main idea in this change is that each 2–3 students form a "design team". Each team is working on designing a different system. They are analyzing and designing the project from scratch, through all the analyze and design steps needed. This allows them to develop a deep understanding of the functional requirements, needs, and possible future design paths of the system, which in turn enables them to produce a high quality design of the system.

The periodic consulting and evaluating meetings of the teams with the course staff members enables the course's staff to direct the students in the right directions. Yet, at the same time, it also sheds light on the students' subjective beliefs regarding the desired design and its future consequences on the system. Thus, allowing for better evaluation of the quality of the students' projects.

Since each team is working on a different system, it is impossible for students from different groups to rely on others. Furthermore, due to the small size of each team it is highly unlikely for the team members to allow one of them to 'leech' and do nothing in this group effort.

Additionally, we incorporated the learning from mistakes approach into the course. Students were given an assignment to design a Class Diagram of their project. Upon submitting their diagram, they were given the design product of another team and were asked to assess its quality and try to identify mistakes in the solution. After thoroughly evaluating the design product of the other team, they were asked to rethink their own design solution, that they built for their system, in light of the new insights they acquired from evaluating the work of a different team and the assessment they received about their own diagram.

Students' final grade was determined based on the evaluation of each individual assignment during the semester and the quality of their final design under the functional requirements that they described.

5. Results

At the end of the study, a comparison was made between the final grades received by the students in the various courses and the final grades given in these courses for two prior years. The goal was to examine whether students' achievements improved because of the changes in the form of the evaluation process. In the Algorithms Course, the final grades in previous years were weighted by 85% final exam score and 15% average grade of the submission exercises. The final grade using the new approach is weighted by 70% final exam, 10% average grade of the submission exercises, and 20% by the CL activity. In the Analysis and Design Course, the final grade in previous years was weighted by 75% final exam score and 25% average grade of the submission exercises. The exercises were based on a case study that the lecturer wrote about a particular organization and the students had to apply the material using the UML diagrams. The final grade using the new approach is weighted by 50% on their final project - the analysis and design of their organization, and 50% average grade of the submission exercises. The exercises were based on all the analysis and design steps needed to obtain the final project. Fig. 1 presents the comparison between the average grades using the new applied assessments approaches and the grades from previous years using the teacher-centered approach, for all courses.

In addition, the students filled out a position questionnaire that relates to the new learning environments approaches, the changes in the manner of assessment, and their added value in the learning process.

5.1 Algorithms course

After the students took both the CL session and the exam, they were asked to fill out a position questionnaire with multi-item scales. The questionnaire contained statements concerning the exam and the CL. The scale range went from 1-strongly disagree to 4-strongly agree. The results can be seen in Table 1.

The questionnaire also contained open-ended questions. Here are some important quotes:

- Concerning the team work:
  - Each member contributed his share in solving the problem. However, I think it is better that the teams will be selected by the course staff, since then there will be more diversity and good students will be able to help other students.
  - We did not manage to work as a team.
  - In team work there can be a situation in which some students are free-riders.
- Concerning the meeting with the course staff:
  - The meeting with the course staff enabled us to show the process we went through in the CL session. It also helped the staff to better understand the students' work.
  - It is hard for me to express myself in a conversation.
  - I express myself better in a conversation than in writing.
- General notes of improvement in the CL session:
  - The difficulty level of the different problems was not uniform.
  - The problems that were suitable for the greedy strategy were easier than the ones suited for the dynamic strategy.
  - There was not enough time.

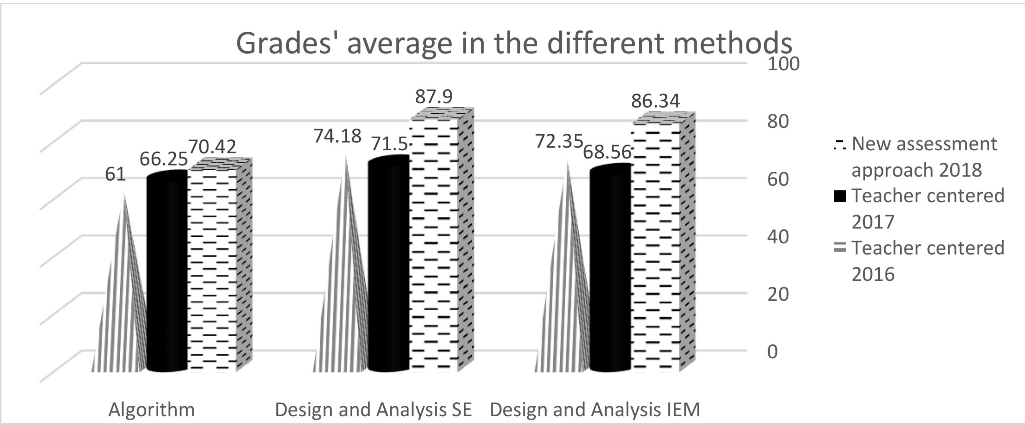

Fig. 1. Average grades in 2016–2018 for the different approaches.

Table 1. Students' responses to the position questionnaire in the Algorithm course

No.	Statement	1	2	3	4
1	The CL session reflected my understanding of the course material.	0%	0%	36%	64%
2	The exam reflected my understanding of the course material.	5%	18%	18%	59%
3	The CL session reflected my abilities more than the exam.	10%	10%	33%	48%
4	The CL session was intellectually challenging and encouraged original thinking.	0%	5%	23%	73%
5	Contributions from the team work in the CL session were helpful.	0%	9%	27%	64%
6	The meeting with the lecturer and TA helped me demonstrate my abilities.	0%	9%	32%	59%

- General notes of preservation in the CL session:
  - In many theoretical subjects it is not easy to understand how the theory works in practice. The practical experience in the subject increases the understanding of the theory.
  - My team and I enjoyed the CL session and it improved our way of thinking.
  - When there is a problem that must be solved it bring out the best of people.

5.2 Analysis and design course

At the end of the semester, after the students submitted the last part of their project, they were asked to come to the last consulting meeting. In this meeting, they were first asked to explain their design, and then reanalyzed their work with the lecturer in order to identify better solutions in places they had difficulties.

Toward the end of the meeting, they were asked to fill out a position questionnaire that contains statements concerning their assessments throughout the PO and Learning from Mistakes approaches. The scale range went from 1-strongly disagree to 4-strongly agree. The results can be seen in Table 2.

Notice that Table 2 contains two different populations that learned the same course. Therefore, it was possible to compare the groups. Hence, for each statement we ran a two–tail T-test between the different populations. Most of the tests showed no significant differences between the two populations. However, in statement #2, discourse learning of theoretical material from the lecturer (namely, in the traditional way), there is a significant difference ($t = 5.85$, $dp = 60$, $p < 0.01$) between the students from the IEM department and the students from the SE department.

The questionnaire also contained open-ended questions. Here are some important quotes:

- Concerning the PO approach:
  - Building your own project from scratch is much more satisfying, motivating and demanding than just doing homework.
  - We were thrown to the deep water which was great, but I think we needed a bigger floating belt at the beginning.
  - I have learned to research the subject, but sometimes you find conflicting information, which can be confusing. Good thing we could contact the lecturer.
- Concerning learning form mistakes approach:
  - Analyzing someone else's work demands a deeper understanding and higher level of controlling the course's subject.
  - As I was analyzing their work and found their mistakes it became clear to me what was wrong in my own work.
  - We needed to analyze other group's work, and their work wasn't clear, so it confused us about our work.
- Concerning the assessments methods:
  - Receiving immediate feedback helped me to move forward in the learning. I could correct myself throughout the learning process.
  - I felt that I had more motivation than usual. This course has a lot of theoretical subjects; I would have never survived it as a regular course.
  - The new approach demands much more work.
- Concerning the team work:
  - Different people—different approaches, there is always something you can learn from others.
  - There are always people that use the group in order to do nothing and still get credit.

6. Discussion

Assessment is essential for achieving the goals of education, and the advancement of engineering

Table 2. Students' responses to the position questionnaire in the Analysis and Design course in IEM Department and SE Department

		IEM				SE			
No.	**Statement**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	The PO approach better reflected my understanding of the course material.	0%	23%	45%	32%	0%	20%	28%	52%
2	Learning theoretical materials with the lecturer helped me reflect my abilities better.	0%	9%	50%	41%	30%	48%	12%	10%
3	Learning from mistakes helped me to better reflect my abilities.	4%	14%	55%	27%	3%	20%	22%	55%
4	The learning from mistakes activity was intellectually challenging and encouraged original thinking.	14%	18%	32%	36%	0%	10%	49%	41%
5	The team work in the PO learning contributed to my understanding.	0%	23%	23%	54%	3%	12%	23%	62%
6	The meeting with the lecturer and TA helped me demonstrate my abilities.	0%	4%	27%	68%	5%	7%	38%	50%

education depends on assessment in many ways [41]. The traditional model of structural engineering education has drawbacks that compromise the quality of the learning [42]. When we limit students to all doing the same test, or the same project, we also limit learning through the assessment process. Instead of using an exam in order to assess the students' knowledge, we integrated AaL and AfL in three different learning environments in two theoretical courses in engineering studies. One of the courses was taught to two different populations in two different departments.

Fig. 1 shows, for all three courses, an improvement in the students' average grades in comparison to past final grades in the same courses. Thus, it appears that adding the AaL and AfL approaches to the course assessment helps students better reflect their knowledge during the course and, as a result, to improve their final grade in the course. The improvement is more pronounced in the Design and Analysis courses. However, this is reasonable, since in the Algorithm course only part of the material was taught in the new approach, while in the Design and Analysis courses the entire course was revamped to support this approach.

Looking at Table 1 and Table 2, in both courses the students felt that their abilities were indeed reflected in the various methods used for assessment. This is an interesting finding, since students are normally disappointed by the traditional assessment method [13].

While most students in the Algorithm course agreed that their abilities were reflected by the exam as well, they still felt strongly that their abilities were better expressed in the CL session. In the Analysis and Design course the two student populations agreed that the two approaches, the PO and Learning from Mistakes, were beneficial to their ability to reflect their knowledge. Yet, while SE students rated both approaches mostly 4 (strongly agree), IEM students gave mostly 3 (agree) to both. This diversity seems connected to the significantly different results of Statement #2 ($p < 0.01$). Where IEM students prefer to learn theoretical material with the lecturer, and SE students prefer to learn using the PO approach.

It seems that the fact that IEM students are at the end of their 3rd year, while SE students are in their 2nd year, makes an impact. Students at the end of their 3rd year are already industry oriented. Most of them already work, and no longer see their studies as the main function they need to accomplish. Most of them prefer the traditional way since both the PO approach and Learning from Mistakes approach demand more work.

Regarding team work, in both populations on both courses, most of the students felt that team work contributed to their understanding. However, the open-ended responses reflected the main problem in team work, which is that some of the students might take advantage of their teammates. It is apparent that the best solution to this problem is to give individual assessments, rather than a group assessment. The ability to differentiate the assessments was possible since each team chose their own project. Also, the personal meeting each student had with the staff members enabled a deeper evaluation of the student's knowledge and abilities.

Yet, the main function of the meetings with staff members was not just to help the staff better evaluate the contribution of each group member, but to help each student better express himself in the assessment process. Looking at the results of Statement #6, in both courses, it is apparent that these meetings with the course's staff members are indeed needed.

Looking at the students' open-ended responses raises a difference between students' desire for project diversity in the courses. In the Algorithm course, students' responses reflect that either all the groups should get the same problem in the CL session, or the course staff needs to fine tune the problems to be at the same difficulty level. However, in the Analysis and Design course students were satisfied that they were given the option to choose their own project idea, despite knowing some will end up with much harder projects. These contrary responses were given from the same students, the SE students that learn in both Algorithm and Analysis and Design courses.

This contradiction becomes understandable when one understands the difference between the two courses. In the Algorithm course students need to cope with and analyze a difficult problem in a limited amount of time. It is not feasible for them to find a problem of their own. Thus, they will have to deal with a problem found by the course staff that they have no personal preference towards. In the Analysis and Design course, students need to analyze and design a system. There is nothing preventing them from inventing their own system, as long as it meets a few ground demands listed by the course staff. Therefore, students develop personal preference and enthusiasm toward their own project.

7. Conclusions

The paper focuses on the effects of implementing different assessment methods in the teaching process using various learning environments. In the Project Oriented approach, the evaluation students receive during the course enables them to fine-tune their final product and submit a more accurate analysis and design of their system. The process was more important than the product of learning. In the Learning from Mistakes approach, students were able to refine their design according to the mistakes that were found by the other student groups. Students are actively engaged in the assessment process and they learn how to use assessment for new learning. In Collaborative Learning, students' abilities were demonstrated by a practical experience in the two algorithmic techniques. By applying the technique on an actual problem, the students understood the concepts and the different essence of the two techniques.

Using learning environments such as learning from mistakes and PO in theoretical engineering courses is an innovative approach. In order to apply a better assessment process in theoretical courses, we combined the AaL and AfL with these learning environments. This in turn enables a more profound learning process.

It seems that in both courses, adding the AaL and AfL approaches made a difference and promoted the students' learning. The improvement can be seen in the level of understanding the students reached, as reflected in the increase in grade scores. It is recommended to examine students' achievements using the new assessment approach in those courses in the next semesters, to see whether the change remains significant and consistent.

The improvement is also apparent from the positive reviews the students gave the change in the questionnaire. Students stated that using AaL and AfL approaches better reflected their abilities in comparison to the traditional way. Also, there are several feedbacks during the course itself; hence, the assessment was more accurate. Furthermore, the research found that using AaL and AfL in theoretical engineering courses increases motivation for learning.

Using the new approach enabled the use of authentic and challenging learning tasks. Organizing such learning environments requires skill and dedication from course instructors, but using such environments allows students to reflect high order cognitive skills, problem solving abilities, and reasoning, which increases the motivation for in-depth learning.

The ways we assess our students can really make a difference to how students learn. High quality assessments can provide information to enhance the students' learning and motivation, which lead to academic outcomes, such as persistence and achievement. Rather than continuing to use exams, we recommend adopting qualitative and diagnostic approaches of assessment in higher education institutions.

In conclusion, in order to leverage the assessment as an opportunity for student learning, we offer some suggestions for educators, based on our experience:

1. Teaching is often changed by the way we assess, so looking at it as part of the learning will make it much more valuable for the learners.
2. It is important to clarify the purpose of the assessment in order to select the method that best serves the learners.
3. Make the students part of the assessment process.
4. Looking on the process of learning is important.
5. Develop activities such as those illustrated here.
6. Throughout the activities, try to elevate the students' enthusiasm so they will feel they are both learning and enjoying.

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