Students Perception on the Impact of Their Involvement in the Learning Process: An Empirical Study

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ABSTRACT

Nowadays, when the changes that appear in programming paradigms and in software process development methodologies are extremely frequent, teaching a Software Engineering related course has become a demanding task. To all these are added changes caused by the dynamics of the society and the traits of the current learners and how they learn.

To cope with the challenges mentioned above, the paper proposes a complementary method for Project Based Learning in teaching two Software Engineering related courses, at undergraduate and master level at Babeş-Bolyai University. Its contribution is twofold: firstly, it frames a new pedagogical approach based on "Students Generating Questions" as a learning strategy, defined in a collaborative way. The approach is supported by an e-learning platform designed as smart learning environment. Secondly, it investigates through a quantitative and qualitative analysis, the students perceptions, their feedback and learning experiences on the use of applying this learning method.

The results of the survey indicate that the proposed learning method helped students to better regulate their learning and to achieve their goals. It also revealed some advantages reported by the students such as reduction of test anxiety, productive collaborative learning and the creation of a question bank which represents a consistent and comprehensive material for training during the semester and for their exam preparation.

CCS CONCEPTS

• **Software and its engineering** → **Designing software**; **Object oriented architectures**; • **Applied computing** → **Interactive learning environments**; **Computer-assisted instruction**.

KEYWORDS

students involvement, feedback, retrieval practice, elaboration, collaborative learning

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1 INTRODUCTION

In a digital era focused on constant change and adjustments towards a better future, the challenge to keep up with the unknown is reflected in every field, including education. Yesterday's methods and tools used for teaching might not be relevant enough for today, and today's ones might be just a training sample for tomorrow's. We are currently preparing students for jobs that don't yet exist. In this context, the focus in the educational system needs to keep up with the time changes, reinforcing the reason for stepping into a new era of education. Thus, teaching and learning methods should be adjusted to the new student's traits and preferences, which make learning more dynamic and experiential. Interactive and collaborative learning within informal and stimulating environments become a necessity.

In respect to this, the scope of this study is to bring light on one methodology of teaching that managed to be relevant and insightful for an entire generation of students that stimulated their interest for an entire semester. Based on the idea that the best learning experience you can have is by experimenting on your own, the study shows how to make this process a desired one for the students, without excluding the valuable knowledge transfer achieved through lectures, seminaries and so on. Thus, a shift in education theory to a more student-centered approach using active learning methods [13], [14], [12] become a necessity.

This paper describes the proposed pedagogical approach based on "Students Generating Questions (SGQ)" learning strategy, defined in a collaborative way. The proposed method is subject to a validation by investigating students perception on the use of this strategy. SGQ encompasses activities like *question and answer elaboration*, *feedback given by instructors and colleagues*, *building an questions bank*, and *retrieval practice*. It was proposed as a complementary method for Project-Based Learning (PBL), thus, the source of inspiration for questions elaborations is the issues encountered during lab project development.

Thus, the goal of this paper is to investigate, by analysing students perceptions, how the use of SGQ can contribute to motivate

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students in two Software Engineering (SE) related courses for undergraduate and master programs. The proposed approach can be extended at any SE related course.

The rest of the paper is organized as follows: Section 2 briefly describes related work regarding students involvement in their learning process. Section 3 outlines the proposed approach, introducing the context, detailing the constituent elements of the complementary approach, i.e., students generating questions and tool support. The research design are outlined in Section 4, while Section 5 outlines the results obtained through a quantitative and qualitative analysis. Section 7 concludes the paper and establishes future research directions.

2 RELATED WORK

There are numerous studies [5], [16], [15] that focus on new methodologies of teaching that are student-centered. The method that we propose has been applied in different circumstances already, and even though in not all cases there was a clear correlation between the grades of the students and the question-pool approach [1], there are clear evidence on the benefits that this method provides, such as exam anxiety reduction and increased productivity [1].

Other papers [19], [10] focus exclusively on the correlation between the hours spent training with quiz questions and the final grade, proving that the more students practice, the better they perform. Besides the quantitative factors that are influenced by these quizzes, other study [18] found that the motivation of students and their curiosity is also triggered by this exercise.

In comparison with similar approaches found in the literature, we believe our study conducts an analysis through various learning activities regarding the student' perception about the impact of the proposed learning method on their learning experience. The distinctive characteristic of our approach lies in the fact that the proposed method is a complementary approach for project-based learning by motivating students to reflect on problems, identified at their lab project, and to share the ideas with their colleagues by enhancing the question bank.

3 PROPOSED APPROACH

The current study addresses a new pedagogical approach based on SGQ method for two Software Engineering related courses that are being taught at our faculty within the Computer Science Curriculum – *Advanced Programming Methods* (APM) taught for *undergraduate* students and *Computational Models for Embedded Systems* (CMES) taught at *master level.*

In the following, we will briefly present first the competences that students need to acquire at APM and CMES courses, the challenges we face when teaching a SE related course, and then we describe in details the proposed learning activities we built and the tool developed, in order to support these activities.

3.1 Setting the Context.

APM is the third course in a package of five introductory courses linked to Software Engineering domain, for all undergraduate students. The students' competences comprised in the APM course syllabus can be summarized as follows:

- Ability to use the concepts, mechanism, and principles of object oriented analysis and design.
- Ability to apply design patterns in different contexts.
- Ability to build software projects with clear separations on architectural layers and by following the main phases in software applications development.

One of the main objectives of the APM course syllabus states that: "Students have to be able to develop *small to medium applications* using the main concepts and mechanisms defined by the object orientation programming paradigm - OOP, together with design strategies expressed in terms of principles, heuristics and rules, and build well defined software architectures for these applications.".

The second course representing the current object study is *Computational Models for Embedded Systems (CMES)* that is taught in the second year to master students at the *Software Engineering* (SE) section and in the first year to the master students at the *Distributed Systems in Internet* (DSI) master section. The specific competences that the students need to acquire are:

- Assimilation of mathematical concepts and formal models to understand, verify, and validate software systems;
- *Analysis, design, and implementation of software systems;*
- Proficient use of methodologies and tools specific to programming languages and software systems;

Among the objectives stated in the syllabus, we mention: know and understand the fundamental concepts of embedded computation, develop skills in modeling embedded systems with various computational models, and acquire theoretical aspects regarding specification, designing and verification of an embedded system.

Software Engineering is one of the main field of Computer Science domain that study the engineering of the design, development and maintenance of software [3]. The challenges of teaching new software engineers is more than just programming, they include also attention to detail, understanding and quality. An important challenge in Software Engineering education arises from the dual nature of the Software Engineering discipline: it both has roots in computer science and has emerged as an engineering discipline. Hence, it involves theory and practice. This characteristic has a direct impact on the amount of material instructors must cover in SE courses. A software engineer has to understand technical challenges and at the same time to have background related to management, communication, and teamwork. Thus, teaching methods have to address both aspects. As an immediate result in this direction, recent studies [2], [17] reveals solid evidence and specific recommendations regarding the strategies that can be used by teachers and students to maximize learning efficacy.

3.2 The Need for a Complementary Method of Project-Based Learning

While for a course related to Software Engineering it is more effective to adopt a Project-Based Learning (PBL) method to develop students' coding skills, there are some shortcomings of this method that need to be addressed.

A project-based homework defined as requirements for lab classes implies students to focus more on the deliverable, and the process that takes the students to an end result falls in a secondary position, not as relevant as the final "product". Many times, students find the "missing piece of code" they need for their project on different websites, a method quite popular among programmers, and they skip the step of understanding why and how the code they borrowed from other sources really works. These aspects are highlighted especially during laboratories, when students ask for feedback from teachers or while they are presenting their homework. Under such circumstances, too often students have a hard time answering questions regarding the code they presented or explaining the logic behind the implementation, ending up admitting that the worldwide web helped more than it should. In the short term, having a functional homework to be graded is what matters for the students. On the other hand, this approach of using random code found online is introducing a lot of disadvantages in the long run. Students start having a hard time in adjusting their project according to the requirements, or applying the theoretical logic in a practical way in order to solve their homework. Moreover, even rephrasing or twisting their work items in an easy manner causes difficulties for them. These disadvantages slowly led towards unconcern from the student side, who stop trying to find answers which might help them in doing their homework.

In order to support students in the process of learning and counteract to the downs of the project-based method of teaching, we propose a complementary solution, which has as primary goal *the process of understanding* new concepts. In this manner, every time the students have a harder time in solving the project and they lack the theory behind what they are implemented, they can create quiz questions and do some research in order to come with an answer and explanation. These questions are collected using a platform, which the teacher responsible for the subject has access to, and the student receives feedback from the teacher, as well as from the colleagues.

3.3 Students Generating Questions

In what follows we describe the proposed activities that are employed for a better learning and engagement of students.

When it comes to teaching and assessment of a Software Engineering related course, where changes in programming paradigms and in software process development methodologies are very frequent, it is very difficult for teachers to come up with comprehensive and consistent learning and training materials to assure the efficacy of learning and assessment. A collaborative approach can be a mean to collect a bank of learning materials and questions for training, with a minimum contribution that every student come up. This way of learning facilitate the learning process and enhance its outcomes. As an immediate solution, a student-centered approach using active learning methods [13], [14], [12] become a necessity. Such an approach has its own role to make the students creative and competent in their study. In this respect, active learning's main drive is to put the responsibility of learning in the hands of the learners themselves and to delegate the role of facilitator to the teacher.

One way to achieve the above-mentioned desiderata is to empower the student to elaborate questions from the course syllabus concepts together with the response and offer a documentation reference. At the same time, the teacher offers valuable feedback and review for students to obtain a comprehensive and complete course material and questions bank. Such an approach, built around active learning methods defines several advantages for students [13], [14], [12], [4]:

- provides him/her the ability to "discover" the knowledge himself/herself, working at his/her own individual speed or in groups in a minimally guided environment, with the lab instructor offering support, encouraging their imagination and creativity;
- puts the responsibility of learning in the hands of the learners themselves and delegates the role of facilitator to the teacher;
- assures an effective learning process, adapted to the specificities of a certain context and needs.

Having all these into account, in what follows, we describe in details the proposed students generating question learning process, emphasizing its main steps and the way it is applied in teaching APM and CMES courses, motivating the importance of these steps in the learning process by the robust empirical support from cognitive and educational psychology.

3.3.1 Question Statement Elaboration. In an academic environment, where the most common teaching method was exposure, questions were used more as a way to assess student knowledge and less as a learning strategy where students are encouraged to elaborate questions. Cognitive studies [2] reveal that questions stimulate the recall of prior knowledge, promote comprehension, build critical thinking skills, and enhance confidence. The art of asking the right questions is not innate and having into account their strong impact on learning, the current paper propose a new learning strategy in this respect.

Each student enrolled in MAP or CMES course has to propose at least one question from a specified syllabus concept as part of the learning process and of their formative assessment. *The first step* in students' generating questions process is to define the question statement and then to link this question to a list of course syllabus concepts and to a list of documentation references and to establish a difficulty level. After this step is completed, the next one refers to response elaboration step.

3.3.2 Question Response Elaboration. Elaboration implies generating an explanation for why an explicit stated fact or concept is true [11]. Different kinds of questions are used to prompt learners to generate explanations, but the majority of studies have used prompts following the general format "Why would this fact be true of this [X] and not some other [X]". As a result of elaboration, the new information is connected to prior existing knowledge and learning is enhanced. Another benefit of elaboration is that the learner has to process both similarities and differences between related entities, and this allows him/her to discriminate among related facts which is very important when identifying and using the learned information [7].

3.3.3 Review and Feedback by Instructors. Feedback enhances learning by revealing to students what they know and what they don't know and, at the same time, it is a strategy for increasing metacognition – our understanding about our own learning process [2]. Regarding the elaboration of the response question from the previous step, studies indicate that, when that technique is used, it is important that students check their answers with the teacher because a poor elaboration content could negatively impact learning [8].

The student can receive feedback to improve the proposed question to be modified accordingly to some standards and difficulty levels imposed by the course. Once a question passes the review process, it is added to the question pool and can be used to create quizzes.

The implementation of this kind of feedback is strongly recommended because studies [6] show that it protects against perseveration of errors by students.

3.3.4 Question Bank. A question back is a container defined by all questions accepted by the course instructor. It can be used to separate exam questions from those offered to the user for training. Some questions selected by teacher are used to be part of the written exam after applying minor modifications or decorating them.

3.3.5 Retrieval Practice. Retrieval practice or practice testing is another learning strategy we have used and this involves the recall of target information in low-stake or no-stake contexts, for formative purposes. It includes also forms of testing that students would be able to engage in on their own. Retrieving the new information implies not just showing the knowing of that information, but, at the same time, it is a way to solidify and expand it [2].

The Question Bank defined at the previous step is used to generate quizzes for students training during the semester. A quiz is a set of questions offered to the user. It is generated by specifying a number of categories and for each category, the number of questions.

3.4 Tool support

The proposed QLearn platform [1] provides support both for students and teachers to design questions to build quizzes (tests), to solve quizzes with varying and progressive difficulty, covering concepts from the course syllabus, to make a review and receive feedback, to keep track of their learning progress. At the same time, students can share their experience and debate certain problems.

Remark: The developed tool is only a support for our proposed methodology, therefore will not be described in details in this paper.

4 RESEARCH DESIGN

This section explains how we planned and executed this study. Section 4.1 presents the study goal and research questions while Section 4.2 discusses the design of the survey.

4.1 Goal and Research Questions

The goal of this study is to investigate how the use of SGQ could contribute to motivate students in two Software Engineering (SE) related courses for undergraduate and master programs. To achieve this goal, we formulated several Research Questions (RQ) targeting various aspects of learning.

RQ1: What is student's perception regarding the ex-tent of which elaboration, feedback and retrieval practice impact their learning?

RQ2: What is the student's perception regarding the usefulness of building a question bank as a training support for their written exam?

RQ3: What are the positive aspects mentioned by students regarding the impact of SGQ method on their learning?

RQ4: What are the improvements aspects and the suggestions reported by students related with SGQ?

4.2 Survey Design

To answer the research questions, we conducted a survey with the students to collect their perceptions regarding the proposed approach. It encompass several questions targeting each perspective of the pedagogical method applied.

The target population was the students enrolled in the APM and CMES Courses. They were invited to participate in this study by e-mail. The students were announced that their participation in the survey was not compulsory and this participation did not provide any benefits in grades. Besides that, the student names were anonymous during the data analysis, to ensure that students would not be embarrassed for giving negative feedback.

The target group was a cohort of 190 undergraduate students (120 males and 70 females) for the APM course, and 54 students (36 males and 18 females) enrolled at the CMES course. The surveys were filled in by 70 APM students and by 13 CMES students, however, all students participated in the courses activities regarding SGQ.

In what follows, we outline the structure of the survey, targeting the steps involved in the student generation question process proposed in Section 3.3.

The survey's questions were designed in a way that allowed us to further analyse the results using both quantitative and qualitative analysis. Thus, six of the questions used a 5-point Likert scale: *To a Very Small Extent*, *To a Small Extent*, *To a Moderate Extent*, *To a Large Extent*, *To a Very Large Extent* to measure the perspectives of the students regarding several statements that targeted the used learning methods. One question asked a ranking of three of the applied learning methods, whereas the last 3 questions ($Q8$, $Q9$, $Q10$) were open ended to allow a qualitative analysis. The survey consisted in 10 questions that are outlines in Table 1.

5 ANALYSIS RESULTS

This section outlines the results of our empirical study, showcasing the discussion of the research questions, reporting on the findings through a quantitative and qualitative analysis, and finalized with answers to the research questions.

5.1 Quantitative Analysis

A quantitative analysis was performed to analyse the responses from the survey questions Q1–Q7 (see Table 1), in a comparative manner for MAP and CMES courses. *These survey questions aim to address RQ1 and RQ2.* These results are described in Figure 1.

The **RQ1** addresses the responses obtained for survey questions (Q1+Q5+Q7) - question and answer elaboration (Q2, Q7) for feedback on question and answer elaboration and (Q3, Q4) for retrieval practice.

Figure 1a) outlines the percentage comparisons between the two disciplines regarding *the questions elaboration* (Q1 from 1), i.e. to

[1]https://maplearn.ro/

No	Question Name	Type
Q1	The elaboration of questions helped me to go through, to reflect and to consolidate the content/concepts in the [APM,CMES] discipline.	Likert scale
Q2	The feedback provided in the elaboration of question and of answer helped me to identify to what extent I understood the contents reflected by the respective questions.	Likert scale
Q3	Learning individually through the QLearn platform and learning through the quizzes offered by the teacher periodically throughout the semester, were important in understanding the contents of the [APM,CMES] disciplines.	Likert scale
Q4	Learning carried out individually through the QLearn platform and learning through the quizzes offered by the teacher periodically throughout the semester, were good preparation for the summative assessment (written exam - Forms) in the [APM,CMES] discipline.	Likert scale
Q5	In the questions developed by colleagues, elaboration of the correct answer helped me to understand the concepts reflected by those questions (ANSWER ELABORATION).	Likert scale
Q6	Questions developed by colleagues (Questions Bank or Questions Set) were useful and consistent material for preparing for the written exam.	Likert scale
Q7	Which of the 3 principles of effective learning mentioned below seem more attractive to you: (1) the elaboration of questions and answer, (2) feedback, and (3) testing over time.	Multiple choice
Q8	What are the positive aspects of SGQ and Testing methods that have created a pleasant learning experience for you?.	Open text
Q9	What are those aspects of SGQ and Quiz methods that need improvement?	Open text
Q10	Make suggestions for your colleagues regarding the way in which they should involve in SGQ learning process next year in order to experience an effective learning.	Open text

Table 1: Survey Questions

what degree the students considered it helpful in consolidation of the taught concepts: the respondents perceive *question elaboration* as being helpful *to a large extent* (46% for MAP and 69% for CMES) and to a *very large extent* (44% for MAP and 31% for CMES).

Figure 1b) delineates the perception of students regarding the *feedback* provided in the elaboration of question and its response (Q2 from Table 1), i.e. if it helped them in identifying to what extent they understood the contents reflected by the respective question. In this case, the responses of the students were spread all over Likert scale, with the tip in large extent for both disciplines.

Figure 1c) and Figure 1d) both refer to the *retrieval practice* strategy (Q3-Q4 from Table 1), one regarding understanding the concepts and the other regarding the summative assessment - defined as quizzes given periodically during the semester by course instructor. For both aspects, students acknowledge *to a large* (31% for Figure 1c) and 37% for Figure 1d) for MAP, and 15% for Figure 1c) and 31% for Figure 1d) for CMES) and *very large extent* (59% for Figure 1c) and 59% for Figure 1d) for MAP, and 62% for Figure 1c) and 54% for Figure 1d) for CMES) the importance of learning through the quizzes for better understanding of the concepts and for the preparation for the formative assessment (written exam).

For question *Q*5 regarding the elaboration of the correct answer, i.e. if they help students to better understand the concepts, for the APM 37% responded with large extent, 39% with large extent, 14% with moderate, 9% with small extent and only 1% with very small extent. For CMES, the answers were: 31% responded with large extent, 38% with large extent, 15% with small extent and only 15% with very small extent. Thus, we may say that the CMES students did not provide proper argumentation/justification for the correct answer.

The answers for the Q7 ranking question revealed that the APM students ranked the three learning methods as follows: 37% elaboration, 26% feedback and 37% retrieval practice. The CMES students choose 46% elaboration, 8% feedback and 46% retrieval practice.

The **RQ2** addresses the responses obtained from survey questions (Q6, Q7) - questions collection defined as a question bank and retrieval space by using this question bank.

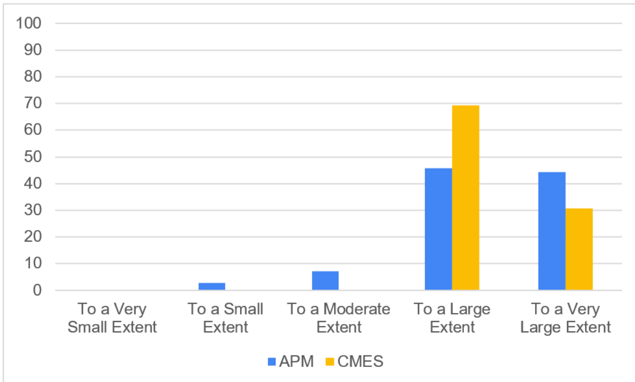
For question *Q*6 regarding the usefulness of the question bank provided by the colleagues, for APM 49% of students responded with *very large extent* and 34% with large extent, whereas for CMES 15% with *very large extent* and 69% with large extent.

For question *Q*7, as stated above, both APM and CMES students liked more elaboration, retrieval practice and feedback (in this order).

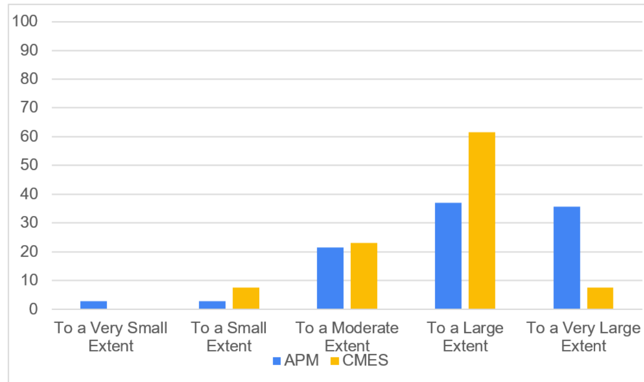
5.2 Qualitative Analysis

A qualitative analysis was performed in order to respond to RQ3 and RQ4. For this, the open text responses of the questions Q8, Q9, Q10 from the applied questionnaire were analyzed using *open coding* method from Grounded Theory approach [9].

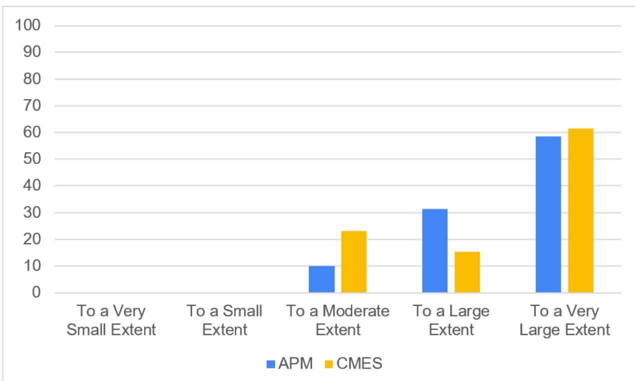
We started with an initial set of labels, and then new labels were added iterative. When a new label was identified by one of the coders, it was communicated to the other coder and discussed. If the authors agreed that this is a valid label, then the coded answers were inspected again together to see whether the new label applies or not. In subsequent iterations, some labels were merged (e.g "understanding was merged with question elaboration"). Conflicts during labeling were resolved through discussion. The results of the open coding are stored in a table, providing labels, terms and the number of responses. This data is used to draw conclusions supporting the research question answer and to build findings.



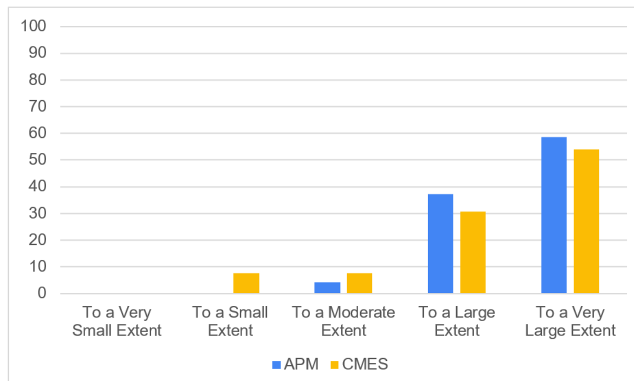
(a) Question Elaboration - Q1



(b) Feedback provided for elaboration of *Q&A* - Q2



(c) Retrieval practice - understanding concepts - Q3



(d) Retrieval practice - summative assessment - Q4

Figure 1: Survey responses (provided in percentages) regarding Elaboration, Feedback and Retrieval Practice

We performed the analysis for both APM and CMES courses and we provide in what follows the details obtained for the APM course, and for CMES outlining the similarities and differences that we identified in student perceptions.

Figure 2 contains the resulted labels and the associated concepts after performing the open coding process for the responses of question Q8 (**RQ3**) of the applied questionnaire. To the main labels that we implicitly considered, i.e. *question elaboration, answer elaboration, feedback and retrieval practice*, were added new ones: *research, space practice, question bank and others*. In what follows, we will discuss the obtained results of the open coding process for the above mentioned question by emphasising some of the concepts that appear with a high frequency between the students responses.

The positive aspect having the highest impact on the student learning process was labeled as *retrieval practice*. Regarding the quizzes applied periodically during the semester, 20 students considered that they impacted or influenced their learning. Others (8 students) viewed these quizzes as a learning by doing approach, whereas some students (12) considered them as an exam revision. Another important aspect to be mentioned here is that students considered that constant testing reduced their stress of making mistakes.

Space Practice was o label identified during the open coding associated with continuous learning during the semester with short breaks. Several students (18) think that learning constantly during the semester increases their progress, decreases exam stress, improves time management for learning, and it represents a good exam preparation.

Regarding the *Answer Elaboration* process, a great number of students (30 out of 70) perceived this method as providing a deep understanding of the learned concepts.

An important label defined by student answers was *research*. Several students (12) saw the research done in answer elaboration as the drive force in their learning process. In the Question Elaboration process, research was viewed by students as a way to find interesting aspects regarding the concepts implied in the elaborated question,

Question Elaboration process was reported by students as providing an opportunity to address issues encountered in their lab project. This is very important due to the fact that the proposed approach was aimed to be an complementary learning methods for project-based learning also. In this case, more students benefits from feedback regarding some issues from their lab project. Students think that Question Elaboration made them more focused on details. Others used the questions as support for their lab assignment.

Question Elaboration		Answer Elaboration		Retrieval Practice (Quizzes)		Research		Space Practice		Question Bank		Feedback	
interesting learning strategy	3	provides deep understanding of the concepts	30	learning by doing	8	finding additional information	12	spreading learning over time	4	high coverage of course concepts	4	received feedback in Answer Elaboration	10
issues from lab	12	elaborate explanations for answer	1	constant testing	20	enjoyed	3	good exam preparation	7	question diversity	4	received feedback in Question Elaboration	6
tricky aspects	2	strengthen teacher-students relationship	1	stress of making mistakes decreased	3	other sources for information	3	reduction of exam anxiety	18	shared informaton	1		
focus/ awareness on details	7			exam review	12	more study	5	progress	2	collaboration for learning	5		
enjoying question elaboration	4			confident	3			time management for learning	1				
Response: %	0.34		0.44		0.59		0.33		0.46		0.2		0.23

Figure 2: Open coding on Positive aspects of the impact of SGQ on student learning (Q8)

A special focus in our proposed SGQ approach was dedicated to the feedback given to students for their question and answer elaboration. In spite of this, few students considered the feedback one of the main aspect that influenced their learning. Studying by research on their own needs, gain advance in front of the feedback.

Several students agreed that the obtained Question Bank offered them valuable training material through a high coverage rate of the course' syllabus concepts, question diversity, and shared information.

For the CMES *open coding* it is important to mention that we have identified some of the same properties for each considered label, for example *research* and *diversified quizzes*. We have also found properties/keywords that only CMES students used like: *revisiting concepts*, *learned better* and *study more*.

Findings. Resuming the above-mentioned students perceptions regarding the proposed SGQ method, we can conclude that students reported a better understanding of the course concepts, gaining during the semester a good preparation for the written exam, and a reduced stress related to making mistakes. At the same time, the applied method made some of them more confident. They also considered that the collaboration strengthened their relationship with the teacher and colleagues and they also enjoyed being empowered by participating in the design of the learning process.

The results obtained for *open coding* for question $Q9$ and $Q10$ (**RQ4**) are discussed in what follows (for APM course), i.e. we have merged the obtained results for the two questions since we notice similarities in the answers of the students. At the same time, we add some quotations of students to highlight their relevant responses to given feedback to improve the proposed method and at the same time offering valuable advises for their colleagues that will be enrolled at AMP course next year.

The results of open coding for questions $Q9$ and $Q10$ revealed students perspectives related with improvements and advice for the next course iteration. The labels identified after open coding was performed were: *Question Elaboration*, *Answer Elaboration*, *Retrieval Practice (Quizzes)*, *Space practice*, *Platform*, *Others*. Therefore, students adhered to some improvement for question elaboration like for instance: *focus on concepts and not syntax*, *propose different type of questions* , *provide useful reference links*, *well explained concise answers*, *use lab project issues as source for question elaboration*. The students also suggested to their colleagues some improvements regarding the reference links they provided and the explanations for both correct answers and incorrect ones. The used platform should be more stable and feature improved offering students valuable analytic and Artificial Intelligence (AI) based component. Last, but not least, students proposed to their next colleagues to adhere to an attitude of learning such as: handle the quiz creation process with confidence and with a sense of responsibility, get involved, focus on understanding, practice during the semester.

The results of the open coding in the CMES course were similar to the obtained results using APM. We have also identified other properties for the considered labels as: *discuss the correct answers during lectures* for the *answer elaboration*, *known your learned level* for *practice retrieval*, and *go to classes* for *other*.

We conclude the section with randomly selected students answers from Q9 and Q10 of the survey regarding their recommendation and feedback for the next generation of students:

- "*I encourage them to handle the quiz creation process with confidence and with a sense of responsibility.*"
- "*Arguments that support the right answer should be as clear as possible.*"
- "*To try to solve and propose as many quizzes as they can during the semester, so they will have an easier time during the exam session.*"
- "*To be rigorous with the explanation they provide [...]*"
- "*Think that the one who will be tested with these is yourself and ask yourselves if you would have enjoyed receiving such a question.* "

Findings. Having all the above discussions and findings into account we can conclude that the proposed approach proved to be very useful for students. They are in this way faced to create questions based on code snippets found in different sources being more involved in *the process of understanding* their hidden layers, or even start *looking for more clarifications* that will facilitate their learning. Having in mind all these, we do not exclude the project-based teaching methodology, but we enhance its importance and the journey of coding by *stimulating the curiosity for research*, using quiz questions created by and for students. The students reported also they embarked in the learning process with more enthusiasm and had fun by doing research, elaborate questions and practice quizzes.

At the same time, analysing the suggestions and improvements proposed by students, these are valuable insights for teachers to make the needed adjustments for the next iteration of the course, in order to build a learning pedagogy that keeps up with the time changes.

6 THREATS TO VALIDITY

Our reported results are based on an empirical study, thus being subject to certain threats to validity. In what follows, we present the major threats to the validity of our research and the ways we tried to mitigate them.

Internal validity refers to factors that could have influenced the obtained results. To reduce possible bias, one of the authors, who was not directly involved in the course execution, was responsible for the invitation of participants and data collection. At the same time, the questionnaire was applied after the end of the examination session, without any concrete benefits (i.e., grades).

External validity concerns the generalization of our findings. A threats to this validity refers to the data collected. It captures only the subjective opinion of the students. A larger number of participants should be interviewed to obtain a general view of a broader audience. However, we had a good number of volunteers to participate in our study. About 40% out of all students of the APM course participated in the survey, but less than 20% took part from CMES course. However, we do not attempt to generalize, but to discuss some interesting issues discovered during this study.

7 CONCLUSIONS

The current paper proposes a complementary approach to project-based learning encompassing questions and answers elaboration by students, practice with the built question bank during the entire semester and also preparation for the exam. The study is directed by a quantitative and qualitative analysis about several survey questions that addressed questions aiming to measure students perception on the impact of the proposed approach on their learning process.

The analysis results showed a positive impact of the use of SGQ method on students learning process by providing o deep understanding of the tough concepts through an individual research activity on their own and a valuable feedback from teacher and colleagues. At the same time, our analysis results revealed the proposed method as being a good support for the exam, makes the students to be more confident on their acquired knowledge, reduces the exam anxiety and that of making mistakes. Valuable suggestions and improvements provided by students will be taken into account for the next iteration of the course.

In the next iterations of the course, we plan to improve the proposed method to better fit with the lab assignment. The improvement will be based on the valuable suggestions received, lessons learned, and insights for future research identified throughout the results analysis process and during the semester.

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