Motivation and Engagement Factors of Undergraduate Students in Computing: A systematic mapping study

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***Abstract*—This paper presents a systematic mapping study on factors that affect motivation in computing undergraduate students. Although there are several initiatives to improve teaching and learning computing, the panorama is still negative. Motivation and engagement are usually singled out as reasons for students' retention or success, but we found a lack of standards in studies on motivation of computing students, and we have not found literature reviews about this subject. We identified twenty-nine (29) motivation factors presented in 32 selected studies. We divided the factors into five categories: student, professor/teaching, program/course/content, environment/university, and social aspects. The most mentioned factor was related to the teaching-learning strategies (37.5%), professor-student interaction (31.3%) and prior knowledge (31.3%). We also have identified that there is no convergence on literature about the identification and measurement of motivation and engagement. Another interesting aspect was that, despite the literature saying that intrinsic motivation has a greater impact on the student's results, many studies are being carried out considering extrinsic aspects. This shows the concern of the computing community regarding these aspects. However, there are only a few studies with controlled studies and evaluations on the impact of the factors in the motivation of students.**

Keywords—motivation, software engineering education, student dropout

I. INTRODUCTION

There are specific reasons that are considered as factors for this high rate of dropouts in computing courses and programs, such as difficulty with programming [*13*] [*14*] and the lack of familiarity of students with the subject [*15*]. However, what are the other factors influencing students to drop out? According to [*8*], more qualitative data and other measures (such as student's expectation) are needed for the broad understanding of the experience of the computer science student.

A factor that is associated with the success or retention of students is their motivation and engagement [*9*]. According to [*9*] and [*10*], motivation is one of the characteristics that influence how students approach their learning. The lack of motivation can cause a strong discrepancy between potential and achievement in learning. This explains why highly qualified students may present poor performance, while students with mediocre potential may figure among the best [*12*].

To improve students' learning and retention in computing, it is important to understand which are the factors that keep them motivated and engaged. Although there are differences in the literature, in general motivation and engagement are considered as two different things. Motivation is the stimulus for the desire to learn something [*13*] or to participate and succeed in the process of learning [*14*]. Meanwhile, engagement involves students spending time, effort, and involvement in learning activities [*15*]. There are various initiatives concerning the motivation of computing students, and most of them propose or report the use of new educational approaches and tools. However, when the issues and factors that influence motivation and engagement are investigated, few studies converge or use categories that may be followed by other researchers, hindering the dissemination and replication of their studies.

The key differential of this work is the categorization and analysis of several studies, allowing it to be a source of more complete and grouped information, focusing on factors that affect the motivation of students in computing. The paper does not intend to address the concepts and epistemology of the issues, neither to discuss the motivation in students from other areas of knowledge, neither to include study cases of teaching approaches. The goal is to explore studies whose main subject is student's motivation in computing undergraduate programs, to give an overview of this factors to facilitate the creation and/or consolidation of assessment models and strategies. In a mapping study, as proposed by [*20*], we would like to discover the research gaps and trends in this subject.

No literature review or systematic mapping studies were found about motivation or engagement of computing students. Systematic reviews were found about motivation in software engineering but focused on professionals [*18*] [*19*]. The literature presents some reviews about Learning Analytics or, more specifically, on the prediction of student dropout or performance, not focused on computing, which mentions some important features to help to predict dropout, including motivation [*23*] [*24*]. The key differential of this work is the categorization and analysis of several studies, allowing it to be a source of more complete and grouped information, focusing on factors that affect the motivation of students in computing.

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II. RESEARCH METHOD

This work is a systematic mapping study on the motivation of students in computing undergraduate programs. It has followed the guidelines proposed by [*20*] with respect to [*39*] findings. The research question is "what are the factors that impact students' motivation in computing undergraduate programs?".

We searched in the following databases: ScienceDirect (Elsevier), ACM Digital Library, IEEE Explore, SpringerLink, PNAS - Proceedings of the National Academy of Sciences, Web of Science, Scopus, MathSci (AMS), CiteSeer, Wiley Online Library, IOPscience Institute of Physics - IOP), World Scientific Electronic & Communication (ProQuest), Science (AAAS), SciELO.ORG, Computers and Applied Sciences Complete (EBSCO), Institution of Civil Engineers, Cognitive Sciences Eprint Archive, DOAB: Directory of Open Access Books, ArXiv.org, Oxford Journals, Computer and Information Systems (ProQuest), AIP Scitation - American Institute of Physics, LSM2 - Logic Substitution Model (IIASA), Cambridge Journals Online, Academic Search Premier – ASP (EBSCO), and ACM Computing Reviews.

We used the following search terms and expressions: computing undergraduate programs or courses: ("computer science" OR "programming" OR "computer science" OR "CS1" OR "software engineering" OR "software development" OR "computing" OR "information systems" OR "coding"), motivation/engagement: ("motivation" OR "motivate" OR "engagement" OR "engage"). We included studies with students in computing undergraduate programs, with discussion or evaluation of relevant factors, published at any year, and written in English.

We did not include (exclusion criteria) studies that do not have relationship with computing undergraduate programs, subjects not related to computer science, studies that describe reports of application of a specific approach or education strategy even if it includes motivation as one factor analyzed, studies that evaluate specifically the issue of gender in computing students (because this factor is already covered in other studies), studies that evaluate only e-learning courses, studies that address elementary, middle, high, or postgraduate students, and other matters which have no direct relation with the motivation in computing undergraduate programs and courses.

As a preliminary result, following the application of the search terms in the databases, we obtained 713 studies. From this first selection, studies not related to computing education were rejected, after title and summary analysis, and 246 studies remained. After the rejection of duplicated studies, 198 studies were left. Of these, the filters (inclusion and exclusion criteria) were applied resulting in 51 studies. We excluded by the criteria of quality other two papers which had no citations, resulting in 49 selected studies. From this selection, we have conducted a brief reading of all studies to assess in more detail the results of each article that were not clear or explicit in the abstract. This analysis has eliminated another 17 studies, for the following reasons: i) two studies were not related to learning (addressing motivation for professionals and experience in the industry); ii) seven studies with full paper not found or not existing (e.g. panels on conferences); iii) two studies about teaching on middle, high or fundamental level; iv) one about teaching in another undergraduate program; v) one about gender issues; vi) one comparison of international surveys; vii) two case studies with proposals for improving strategies of motivation, but without analyzing of motivation itself; viii) one study repeated in other paper. Finally, it has remained 32 studies. After data tabulation, extraction and reading, we consolidate the results found in the following section. The list of all selected papers and more details are available on https://goo.gl/nW8xPZ.

III. RESULTS

Most of the 32 selected studies are recent, having a significant growth in the last decade. We highlight that the period from 2013 to 2016 has 17 selected studies (53% of the total). Considering the last 10 years, we have approximately 80% of the selected studies. This demonstrates that the subject is a current concern in computing. Table I shows the results by category, identifying the number of studies that use each category to classify motivation.

TABLE I: STUDIES BY CATEGORIES OF MOTIVATION/ENGAGEMENT

Category	Studies	% Studies
Demotivation/lack of motivation	14	43.8%
Intrinsic motivation	13	40.6%
Extrinsic motivation	11	34.4%
Realization	10	31.3%
Attitude/engagement	8	25.0%
Motivation in General	7	21.9%
Social Motivation	5	15.6%
Expectation x value	2	6.3%
Others	8	25.0%

The amount of studies is greater than 32 because each study can deal with more than one category. None of the categories is present in all studies; moreover, the most used category is present in only 14 studies (43.8%). This demonstrates the lack of standardization in the analysis of motivational categories. Another important point, as Table I shows, is that demotivation or lack of motivation is the most cited category, which shows that researchers are concerned about identifying this category and its motives. A significant number of studies (11) classifies motivation into intrinsic or extrinsic. To classify the factors found, we divided them into five categories: student, professor/teaching, program/course/content, environment/university, and social, as well as their respective subcategories. All of them are described below. Table II describes the factors of each category. Category "student" group factors related to the behavior and characteristics of the students. Category "professor/teaching", which brings factors related to professors and the teaching-learning process. Some factors are duplicated because they are part both of the "students" category as well as the "professor/teaching" category. Factors of categories "program/course/content, environment/university, and social (external)" refer to the structural aspects of the program and facilities the university, besides the influence of factors external to the university environment.

Table III shows the frequency of factors described in selected studies, for each category, as well as the number of studies that mention at least one factor in the category.

TABLE II: MOTIVATION FACTORS OF THE "STUDENT" CATEGORY

Factor	Description	Sub-factors
Student category		
Student-professor interaction	It refers to the frequency and quality of the professor-student relationship. It is related to the support and openness to discussions by the professor, communication, and coexistence between professor and student, as for the number of emails and information exchanged between students and professors.	- Quality of interactions between student and professor - Access to activities and materials in the Learning Management System - Amount of digital interactions between student and professor - Inclusive learning community - Feedback and help from the professor - Promotion of discussions
Prior knowledge	Refers to the knowledge acquired by the students prior to their entry into the university, from their general and broad knowledge, until their ability to programming and computing in general.	- Performance in high school - Broad and social vision of the area - Perception of the area and nature of the course - Previous knowledge in programming - Quantitative reasoning
Future aspirations	Refers to the student's desire for the future, related primarily to the professional future, but also to the application of the content in the real world.	- Career/ employment opportunities - Use of computing in other areas - Be the basis for future specializations
Participation	Refers to the effectiveness of student participation in class, involving presence, extra classroom studies, and participation in activities.	- Presence in class - Extra classroom study - Completion of the proposed activities
Reason to be attending	Refers to the initial reason to choose and attend computing.	- Reason to enter the course
Experience	Refers to the time of prior experience in computing.	- Professional experience - Programming experience - Experience in the course
Confidence	Refers to how confident the students are with what they are learning, related to the efficacy and self-regulation.	- Self-confidence
Gender	Refers to the influence of gender on performance and motivation of the students.	- Gender
Behavior	Related to the fears, attitudes, and mentality of students.	- Attention - Growth mindset (think that can improve) - Fear - Behavioral engagement (effort, persistence) - Emotional engagement (affection, interest)
Learning	Refers to the pleasure to learn and apply knowledge, beyond the perception of their learning level.	- Self-efficacy (perception to be able to learn) - Learning at high levels (Bloom's taxonomy) - Pleasure in learning - Desire to apply knowledge
Satisfaction/ entertainment	Refers to how much pleasure and fun are the activities.	- Satisfaction/feeling happy - Fun (teaching-learning process enjoyable/funny)
Practice/ study	Refers to the way of study, involving time management, available resources and practical activities outside the university environment.	- Activities outside the university context - Studying right (time management, problem-solving) - Mature study practices
Independence	Freedom and autonomy of the students to participate in the discussions and definitions of the activities.	- Independence of students (participation in decisions, activities)
Professor/teaching		
Teaching-learning strategies	Refers to how the professor addresses teaching practice, types, and varieties of pedagogical activities.	- Interesting examples - Fun environment - Diversity of approaches - Relevant to the market and updated information - Improving team spirit - Active learning, practice - Collaborative learning - Promoting reflection
Student-professor interaction	Described in the student category	
Level of difficulty	Refers to the adequate difficulty level of contents (neither easy nor difficult).	- Adequate difficulty level - Self-efficacy (perception of being able to learn)
Defined and relevant goals	Refers to the explicit definition of discipline goals and how important they are.	- Clear learning goals - Understanding of contents relevance
Professor issues	Refers to items related to training, abilities, and gender of the professor	- Training of professors - Education background of professors - Gender
Satisfaction/ entertainment	Described in the student category	
Independence	Described in the student category	
Reward and recognition	Professors recognize and value tasks well performed	- Reward and recognition
Punishment	Refers to the existence or not of punishment, in addition to its application form.	- Punishment
Challenges	Existence of challenging and intriguing goals.	- Challenging goals
Assessment	Flexibility of the assessment to meet all kinds of students.	- Flexible assessment
Other categories		
Course/ content	Refers to the actual content of the course, its curriculum, and syllabus.	- Course content - Distaste for programming - Challenging and interesting area - Type of the course (class shift, emphasis) - The course aimed at the market
Programming language	Refers to the programming language used in teaching.	- Programming language(s) used in teaching
University environment	Refers to the learning environment, the support provided by the university and students' socialization.	- Socialization within the class - Adequate support environment - Student interaction with the University
Virtual environment	Impact of having or not an adequate virtual environment.	- Adequate virtual environment
Social influence	Refers to the influence of some friend or family member and to social pressure to choose or remain in the course.	- Influence of family/friends - Society pressure

TABLE III: IMPACT FACTORS ON MOTIVATION/ENGAGEMENT

Category	Studies	% Studies
Student	26	83.9%
Professor/teaching	20	64.5%
Course/content	10	32.3%
Environment/university	6	19.4%
Social (external)	5	16.1%

Grouping all the factors by incidence, only three of the most cited factors can be linked directly with intrinsic motivation: learning (7), student behavior (7), and prior knowledge (10). The other are factors that receive interference from external agents, such as teaching strategies (12), student-professor interaction (10), future aspirations (8), course/content (8), difficulty level (7), and defined and relevant goals (7).

This result seems to go against the belief that the intrinsic factors are the most important because most of the mentioned factors refer to aspects that may be changed, improved, and controlled externally. This allows us to make two observations that need to be investigated with greater control: i) current studies are not measuring all the factors that affect the motivation of students; ii) there are factors that may influence the change of motivation throughout the course or program. We have found that little more than half of the studies (53%) use some model/protocol previously proposed. However, only two equal models/protocols were used in two different studies. The other 13 studies were based on 13 other different previous models/works; that is, none of these was reused.

IV. DISCUSSION AND CONCLUSION

This work presents a systematic mapping study to identify factors that affect the motivation and engagement in computing undergraduate students. We have identified 32 relevant studies. We have identified that a significant number of studies assess motivation using the categories of intrinsic and extrinsic motivation, as well as many studies seek to identify demotivation or lack of motivation of the students. Nevertheless, we have noticed that there is no standardization in this categorization since the category most used was mentioned by only 43% of the studies. We have identified several factors, which were grouped into five categories: student, professor/teaching, program/course/content, environment/ university and social (external) and respective 29 subcategories (factors). As a result, a large part of the studies deals with the factors related to the student and professor/teaching, but the minority considers factors related to the program/course/content, university environment, and social aspects. This demonstrates that the current studies are not extensive, often limited to work with only some specific factors.

It can also be demonstrated a lack of standards in studies on the motivation of computing students, that assess different sets of factors (considering that the most used factor – teaching strategies – was cited by less than one-third of the studies), what may be due to too specific or limited studies. According to [*43*] and [*28*], students with intrinsic motivation have better results and greater success. As the intrinsic motivation refers to the fact that the students are attending the course or program because they like it and are interested in computing, factors like "reason for attending" and "learning" should be the most frequent. However, we have noticed that these factors are reported only by a little more than 20% of studies. The most mentioned factors were related to the teaching-learning strategies (37.5%), professor-student interaction (31.3%) and prior knowledge (31.3%). This indicates that the current studies are considering and concerned about the impact of the learning-teaching process in students' motivation, suggesting that the motivation/engagement may vary throughout the undergraduate program as students interact with the educational components.

These results indicate that there are issues not fully covered in the literature about the factors that impact on motivation/engagement of computing students. The results also indicate that the current studies related to computing students are not following a standard with respect to the model or protocol used, which can hinder replication studies and comparison of results. The possible reason for that is that standards and models covering all aspects and factors identified are lacking

Another finding was that the existing models mostly aimed at assessing the motivation/engagement in a specific moment of the student cycle. However, we have understood that it is important to monitor the motivation/engagement of the student during all the undergraduate periods. Another interesting aspect we have identified was that, despite the literature saying that intrinsic motivation has a greater impact on the student's results, many studies are being carried out considering extrinsic aspects, previous and social factors, self-realization, among others. This can demonstrate the concern of the computing community with aspects that can be somehow affected by the academic institutions involved. On the other hand, we found only a few papers presenting controlled studies and evaluations on the impact of the factors in the motivation of students.

It is possible to create several actions and tools to improve the teaching-learning quality and students' retention, based on the mapping of motivation factors. For example, identifying that students are dissatisfied with the "Level of difficulty" factor may indicate lack of prior knowledge of some subject or that teacher is overcharging beyond that expected. Another example, a poorly evaluation for "Teaching-learning strategies" factor may indicate that teachers are not varying their teaching strategies, and this may be doing classes boring and may not suit all student profiles. One solution would be to train teachers in new pedagogical approaches, for example. From the definition of these variables, it is possible to construct computational tools, using data mining, machine learning, and statistics to support decision making and to discover information and connections for predicting and advising people's learning.

From the mapping of motivation factors, it is also possible to create specific instruments for measurement and control. For example, tools can be created to evaluate pre-university factors in order to check what actions in schools or entry selection for freshmen can be made. Or create instruments to identify satisfaction with the factors related to the program, to verify the need and critical points for a curricular reform. Or create an instrument to identify factors related to teachers and classes, in order to plan actions for training and definitions of teaching strategies. Or create instruments to identify factors for dropping out students.

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