Evaluation of an Instrument to Identify Factors that Impact the Motivation and Engagement of Undergraduate Students in Computing

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***Abstract*—This Research Paper presents the evaluation of an instrument to identify the impact of motivation and engagement factors in undergraduate students in computing. Although researches indicate a direct impact of motivation and engagement on student performance and retention, few studies have been found that address which factors are relevant in this process. The instrument is a questionnaire based on the compilation of several works of the literature containing 48 items divided into 6 groups: personal and demographic data, general perception about motivation, perception about the university, student behavior, perception about program and perception about classes/teachers. The questionnaire evaluation is based on a case study with 112 undergraduate students in Software Engineering. As a result, we found that the questionnaire can be considered reliable (Cronbach's alpha = .8904). Considering the validity of constructs, we found an acceptable degree of correlation between the most pair of items in each group (averaging 63%). We also found that the item-total correlation coefficient was only not adequate for one factor group, indicating satisfactory correlation for all other items. Finally, we found that the number of factors is coherent, but there are several items from different groups strongly correlated, indicating the need for a reorganization.**

Keywords—motivation, software engineering education, student dropout

I. INTRODUCTION

The high dropout and failure rates in computing programs remain a challenge in the computing education area. Some studies describe worldwide dropout rates up to 40% in computing and technology undergraduate programs [*1*] [*2*]. In some developing countries, such as Brazil, studies show an average rate of evasion equal to or greater than 40% [*3*] [*4*].

In this context, a factor that is associated with the success and retention of students is their motivation. According to [*5*], motivation is one of the characteristics that influence how students approach learning and, according to [*6*], motivation is important in academic performance. One reason why students give up is low motivation for studies, which in turn can influence learning outcomes [*7*].

Lack of motivation can cause a strong discrepancy between potential and success in learning. This explains why highly skilled students have poor performance, while a student with mediocre potential may be among the bests [*8*].

There are several reasons that can be considered factors for demotivation and consequently generate a high index of failure, including specific factors in the area, among which the difficulty of students with computer programming [*9*] [*10*]. And the lack of familiarity with the subject [*11*]. Another factor addressed by some studies is that many novice students relate STEM disciplines (Science, Technology, Engineering, and Mathematics) as being interdisciplinary and innovative. However, this view is often not confirmed by the first experiences in the university, bringing disappointment and doubts [*12*].

But are these the only factors that impact on student evasion? According to [*13*], more qualitative data are required and other measures (such as student expectation and some specific measure) are necessary for the wide understanding of the experience of the computer science student.

We consider that the first step towards an improvement process in this scenario of high rates of failure of students in computer courses is to understand the current problems and to search for potential alternatives of the solution. In this way, aiming at the highest student index successfully completing undergraduate courses in computing, it is important to understand what makes students stay motivated and engaged in the course, which will possibly produce better performance and highest success rate.

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There are various initiatives concerning the motivation of computing students; most of them propose or report the use of new educational approaches and tools [*14*] [*15*] [*16*]. 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.

In this context, this paper proposes and validates an instrument to identify factors that can affect the motivation and engagement of computer students. The instrument was defined based on a compilation of literature works [*Anonymous*, 2018]. As the main contributions of this work, we have:

- Compilation of various factors that can affect the motivation and engagement of students;
- Creation of a light scale of motivation, based on the styles of motivation: intrinsic, extrinsic, social, realization and amotivation;
- The availability and validation of an instrument so that other researchers can use it for new studies.

This paper is divided as follows: i) in Chapter 2 a contextualization of motivation and state of the art is presented; ii) in Chapter 3, the methodology used is described; iii) in Chapter 4 the results are presented; iv) in Chapter 5, the results are discussed; v) The conclusions of the work are presented in Chapter 6.

II. RELATED WORKS

This work presents a proposal and validation of an instrument for identifying factors that can affect the motivation and engagement of computer students. Therefore, we present other instruments that are related to this work.

The Motivated Strategies for Learning Questionnaire (MSLQ) [*17*] is a questionnaire based on a cognitive vision of motivation and learning strategies. This questionnaire consists of two sections: i) the first with 31 items to evaluate the student's values, expectations, and affection; ii) The second section has 31 items to evaluate the use of different cognitive and metacognitive strategies by students, in addition to 19 items to evaluate the management of different resources by students.

The Students' Motivation Toward Science Learning (SMTSL) [*18*]. It is a questionnaire to measure the motivation of students for learning science. It is divided into 36 questions with answers from 1 to 5 (Likert scale) and 5 Scales: i) effectiveness – belief in their ability to perform activities well; ii) active learning strategies – the use of various strategies to build new knowledge based on prior understanding; iii) value of learning science – finding the relevance of science in everyday life; iv) performance objectives – compete with other students and gain attention from the teacher; v) stimulating learning environment – curriculum, faculty, and student interaction.

The l'Échelle scale of motivation in education (EME) was developed in Canadian French by [*19*]. This scale assumes the multifactority of the motivational processes. It is composed of 28 items and punctuated on a Likert scale with seven points. EME was subsequently translated into English, originating the Academic Motivation Scale (AMS) [*20*].

The theoretical or structural factorial model of EME and AMS presents the intrinsic motivation in the way of the subscales: intrinsic motivation for knowledge (IMK), intrinsic motivation for realization (IRR) and intrinsic motivation to experience stimulation (IMES). In addition to the subscale of motivation (AMO), the model also has three other subscales that group the various ways of extrinsic motivation: by identification (EMId), by introjection (EMIn) and by external regulation (EMER).

The Student Engagement Instrument (SEI) [*21*] is a questionnaire to measure student engagement, containing 30 items that aim to measure the level of student cognitive engagement and 26 items aimed at examining the psychological engagement of the student's perspective. All items are evaluated on a 4-point Likert scale. The items are divided into 5 groups of factors: i) student-teacher relationship; ii) control and relevance of activities; iii) peer support for learning; iv) future aspirations and targets; v) family support for learning.

The Student Experience Survey (SES) or University Experience Survey (UES) [*22*] was created to measure the level of engagement and satisfaction of first and last year students at the Universities of Australia. Consisting of 5 question groups: student engagement, teaching quality, learning resources, student support and skills development. The engagement group contains 7 issues, which generate a scale and an engagement index: i) feeling prepared for studies;) sense of belonging to the institution; iii) online or face-to-face discussions; iv) working with other students; v) student interaction outside the class; vi) interaction with different students and; vii) opportunities to interact with local students.

Despite the importance given to the motivation and engagement in the success of students, few works in this context were found in the area of Computing. A previous study worked out the review of studies about motivation in computing area [*Anonymous*, 2018]. That work found only 32 studies that mentioned factors that affect the motivation of computing students.

In addition to measuring and identifying motivation, it is important to understand the factors that affect such measures. Assuming that there are factors that may be specific to the area and seeking to compile the factors that are being carried out in studies in the field of computing, the systematic revision [*Announimous*, 2018] identified 38 factors divided into 5 groups: student, professor/teaching, program/course/content, environment/university, and social, as well as their respective subcategories.

The differential of this work is the proposal and validation of a scale to identify factors that affect the motivation based on the unification of several factors reported in the literature, not specifically in a discipline or activity; furthermore, this work is specific to the Computing area.

III. RESEARCH METHOD

This work aims to validate an instrument to identify motivation factors in computer students. The instrument was built based on a group of factors compiled from several works of literature [Anonymous, 2018].

In order to perform an evaluation of the questionnaire, we conduct a case study as follows:

Preparation: definition of the study goals.

Execution: i) apply the instrument to Software Engineering (SE) students; ii) collect and organize data from case studies.

Analysis: i) internal consistency reliability (Cronbach's alpha); ii) convergent and discriminant validity (intercorrelation of the scale items and item-total correlation); iii) factorial validity (factor analysis).

In the preparation phase, we defined the study goal to analyze the questionnaire in order to evaluate the reliability and construct validity from the viewpoint of students in the context of SE programs. The goal was decomposed into analysis questions to be assessed based on the data collected on the case studies.

Regarding the sample size, there are several studies in the literature that suggest different sample size to factorial analysis, from 50 to 1000 [*23*] [*24*] [*25*]. For this work, we based on [*25*], that suggests the minimum sample size should be 100 to reach acceptable effect size of 0.29 (as defined by [*26*]).

The execution phase was based on the application of a questionnaire (survey) to 112 students of the Bachelor Program on Software Engineering at University of Santa Catarina in Ibirama - Brazil. The development and implementation of this survey were based on the process described by Kasunic [36].

The analysis phase aims to measure reliability and validity of the instrument. Reliability is the agreement between two efforts to measure the same trait through maximally similar methods. Validity is represented in the agreement between two attempts to measure the same trait through maximally different methods [*23*].

In terms of reliability, we measured internal consistency reliability based on the correlations between different items in the questionnaire. We also measured internal consistency through Cronbach's alpha.

In terms of construct validity, convergent and discriminant validity are the two subcategories of construct validity [*24*]. "Convergent validity refers to the extent to which different methods of measuring the same trait yield similar results" [*25*]. In contrast, discriminant validity refers to the extent to which similar or identical methods measuring different traits lead to different results [*25*]. To analyze the convergent and discriminant validity of the questionnaire, we calculated the intercorrelations of the items and item-total correlation. Intercorrelation refers to the degree of correlation between the items [*25*] [*26*]. The higher the correlations among items that measure the same factor, the higher the validity of individual items and, hence, the validity of the instrument as a whole. Item-total correlation is analyzed in order to check if any item in the questionnaire is inconsistent with the averaged correlation of the others, and thus, can be discarded [*25*] [*26*].

In addition, we used factor analysis (FA) to determinate how many factors underlie the set of items of the questionnaire. FA consists of a variety of statistical methods for discovering clusters of interrelated variables. Each factor is defined by those items that are more highly correlated with each other than with the other items. When the factor loading is higher, the particular item contributes more to the given factor [*25*].

The reliability of the questionnaire is measured by Cronbach's alpha coefficient, which measures the internal consistency. We measured the validity of the instrument by analyzing the intercorrelation between the items according to the Spearman correlation matrices and we analyzed the item-total correlation to evaluate the contribution of each item. To verify if the number of factors that represent the answers to the items is coherent, we used the factorial analysis and principal components analysis.

IV. THE INSTRUMENT

It was worked out a questionnaire with 48 items, including the motivation factors of the literature review [*Announimous*, 2018], demographic and entrance data of the students at the university and a light scale for measurement of motivation. The items are divided into six groups as shown in Table I: personal and demographic data, general perception of motivation, university perception, student behavior, course perception and class/teacher perception.

Groups 3, 4, 5 and 6 of the questionnaire were based on a compilation of factors extracted from the literature. Each item has options following a Likert scale of 4 points (SA – strongly agree, A - agree, D - disagree, SD – strongly disagree). "*Respondents' desires to please the interviewer or appear helpful or not be seen to give what they perceive to be a socially unacceptable answer, can be minimized by eliminating the mid-point ('neither ... nor', uncertain, etc.) category from Likert scales*" [37].

The group "general perception of motivation" is a light scale adapted from Vallerand [38] and Jenkins [10].

TABLE I. QUESTIONNAIRE GROUPS AND FACTORS

Group	Factor
1. Personal and demographic data	1A – Gender 1B – Quota 1C – Entrance exam position 1D – Age 1E – Way of entering
2. General perception of motivation	2A – General level of satisfaction with the program 2B – Reasons to continue studies 2C – Level of intention to continue studies 2D – Reasons to dropout 2E – Self-efficacy
3. Perception about University	3A – Adequate student support 3B – Adequate learning resources 3C – Adequate LMS (learning management system) 3D – Level of satisfaction of faculty 3E – Graduation and qualification of faculty
4. Student behavior	4A – Feeling of being prepared for the study 4B – Interaction with students outside of the academic environment 4C – Sense of belonging to the University 4D – Interaction with different students 4E – Participation in discussions with students and teachers 4F – Group work with other students 4G – Attendance 4H – Commitment to activities and deadlines

	4I – Studying in the correct way and proper time managing for activities 4J – Trying to do more than requested 4k – Doing the best to stand out in the class
5. Perception about program	5A – Installations of industrial importance and updated 5B – Alignment with the job market 5C – Appropriate type of program and courses (the focus of course in computing, schedules, etc.) 5D – Appropriate curriculum (syllabus) and program of courses (contents) 5E – Ease of insertion in the labor market and prospects for the future 5F – Balance between areas of knowledge allowing a systemic vision 5G – Proper teaching quality
6. Perception about course and professor	6A – Active learning 6B – Fun 6C – Challenges 6D – Peer learning 6E – Diversity of pedagogical approaches 6F – Team spirit 6G – Practice outside the classroom 6H – Utility and future application of the contents 6I – Participation of the student in decision making 6J – Reward to the effort 6K – Information provided 6L – Adequate difficulty level 6M - Clarity in the goals of the course 6N – Students with difficulty are not exposed 6O - Gender distribution of faculty

V. PREPARATION AND EXECUTION OF THE STUDY

The questionnaires were applied in the period from November 27th to December 1st, 2017, at all semesters of the program, totalizing 112 replies.

With the objective of assessing the quality of the instrument to measure motivation factors in computer students, we defined the following analysis questions (AQ):

Reliability

AQ1: Is there evidence for internal consistency of the questionnaire?

Construct Validity

AQ2: Is there evidence of the convergent and discriminant validity of the questionnaire?

AQ3: How do underlying factors influence the responses on the items of the questionnaire?

VI. ANALYSIS

We analyzed each of the analysis questions as defined in the research methodology.

A. Reliability

AQ1: Is there evidence for internal consistency of the questionnaire?

We measured the internal consistency of the questionnaire through Cronbach's alpha coefficient [*27*]. It describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test [*28*]. Thus, we want to know whether the questionnaire measures the same quality factor, the factors that affect student motivation and engagement. Typically, values of Cronbach's alpha, ranging from 0.70 to 0.95 are reported as acceptable [*28*], indicating internal consistency.

The value of the Cronbach coefficient for the entire questionnaire was satisfactory (0.8904). Analyzing by questionnaire group, we can see the following results of reliability: i) general perception of motivation – 0.6429; ii) perception about university – 0.6503; iii) student behavior and engagement – 0.8416; iv) perception about the program – 0.8037; and v) perception about classes and faculty – 0.9006.

We can see that two groups have gotten the coefficient a little below the acceptable. Regarding the group "general perception of motivation", the fact that we use different scales for the items answers may have impacted on the result. Regarding the group "perception about the university", we identified that there are 2 items in this group that are related to faculty (career satisfaction, faculty training, and qualification) and, because of this, the internal consistency of the group may have been changed.

B. Construct Validity

AQ2: Is there evidence of the convergent and discriminant validity of the questionnaire?

To establish evidence of the convergent and discriminant validity of the items of the questionnaire, we calculated the intercorrelations of the items and correlation item-total.

Intercorrelations of the items: the first quality we seek in a set of scale items is that they should be highly intercorrelated. One way to determine how intercorrelated the items are is to inspect the correlation matrix [*26*].

TABLE II. INTERCORRELATION– PERCEPTION ABOUT THE UNIVERSITY

	3A	3B	3C	3D	3E
3A	1,000				
3B	0,285	1,000			
3C	**0,295**	**0,383**	1,000		
3D	0,227	0,247	**0,367**	1,000	
3E	0,107	0,252	0,272	**0,482**	1,000

According to Table II, the number of significant correlations was 4 (40%) to the "perception about university" factor group. However, all other correlations had positive values and most of them close to the minimum value considered acceptable (0.29).

TABLE III. INTERCORRELATION– STUDENT BEHAVIOR

	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J
4A	1									
4B	.262	1								
4C	**.348**	**.427**	1							
4D	.112	**.471**	**.364**	1						
4E	.277	.274	**.356**	**.432**	1					
4F	.270	**.416**	**.381**	**.459**	**.393**	1				
4G	**.403**	.157	.231	.039	.262	.262	1			
4H	**.304**	.150	.155	.234	.255	.224	**.414**	1		
4I	**.505**	.178	.197	.151	.281	.267	**.348**	**.460**	1	
4J	**.504**	.094	.174	.158	**.391**	.250	**.518**	**.351**	**.481**	1
4K	**.461**	.152	.163	.067	.289	.210	**.405**	.287	**.544**	**.703**

According to Table III, the number of significant correlations was 25 (45.5%), in bold, for the "student behavior" factor group. However, all other correlations had positive values and most of them close to the minimum value considered acceptable (0.29).

TABLE IV. INTERCORRELATION– PERCEPTION ABOUT THE PROGRAM

	5A	5B	5C	5D	5E	5F	5G
5A	1,000						
5B	**0,412**	1,000					
5C	0,283	**0,537**	1,000				
5D	0,160	**0,474**	**0,646**	1,000			
5E	**0,446**	**0,425**	**0,387**	**0,421**	1,000		
5F	**0,449**	**0,356**	**0,492**	**0,404**	**0,489**	1,000	
5G	**0,410**	**0,357**	**0,407**	0,273	0,262	**0,426**	1,000

According to Table IV, the number of significant correlations was 17 (81%), in bold, to the "perception about program" factor group. However, all other correlations had positive values and most of them close to the minimum value considered acceptable (0.29).

According to Table V, the number of significant correlations was 72 (68.6%), in bold, for the "perception about courses and teachers" factor group. However, all other correlations had positive values and most of them close to the minimum value considered acceptable (0.29).

TABLE V. INTERCORRELATION OF ITEMS – PERCEPTION ABOUT COURSES AND PROFESSORS

	6A	6B	6C	6D	6E	6F	6G	6H	6I	6J	6K	6L	6M	6N	6O
6A	1,000														
6B	**0,326**	1,000													
6C	**0,486**	**0,644**	1,000												
6D	**0,370**	**0,440**	**0,571**	1,000											
6E	**0,380**	**0,366**	0,285	**0,373**	1,000										
6F	0,285	0,250	**0,313**	**0,360**	**0,467**	1,000									
6G	**0,375**	**0,331**	**0,389**	**0,441**	**0,567**	**0,512**	1,000								
6H	**0,325**	0,283	**0,304**	**0,349**	**0,465**	**0,408**	**0,521**	1,000							
6I	**0,342**	0,276	**0,330**	0,271	**0,448**	**0,484**	**0,595**	**0,509**	1,000						
6J	**0,301**	**0,290**	0,211	0,210	**0,364**	0,266	**0,426**	**0,460**	**0,471**	1,000					
6K	0,173	0,251	0,202	0,249	0,250	**0,394**	**0,423**	**0,402**	**0,385**	**0,450**	1,000				
6L	0,281	0,111	0,228	**0,414**	**0,318**	**0,347**	**0,502**	**0,394**	**0,504**	**0,304**	**0,370**	1,000			
6M	**0,308**	0,239	0,168	0,209	**0,387**	0,263	**0,467**	**0,435**	**0,332**	**0,452**	**0,388**	**0,473**	1,000		
6N	0,087	0,019	0,004	0,182	**0,302**	0,228	**0,331**	**0,292**	0,252	0,177	**0,324**	**0,402**	**0,421**	1,000	
6O	0,224	0,001	0,072	0,169	0,217	**0,307**	**0,361**	**0,363**	**0,415**	**0,449**	**0,385**	**0,499**	**0,488**	**0,377**	1,000

We have identified that, in general, most of the items that are part of the same constructor have an acceptable correlation. Similarly, no negative correlation within the same constructor was found. Therefore, we observe evidence that the items of each constructor are correlated, indicating evidence of convergent validity.

On the other hand, we found some correlations between items of different groups (16%), more frequently between items in the group related to the university and program (34%), as well as between program and faculty/courses (52%). For example, item 8.7 (proper teaching quality) has a significant correlation with all items in the university group.

Item-total correlation. This test aims to evaluate the correlation of each item with all the other items. Each item of the instrument is considered consistency if it has a medium or high correlation with all the other items [*26*]. On the other hand, a low item-total correlation of an item undermines the validity of the scale, and, therefore, should be eliminated. For this analysis, we used the method of corrected item-total correlation, which compares one item with every other on the instrument, excluding itself. In addition, we analyze the Cronbach's alpha if an item is removed. It is expected that no item should cause a substantial decrease in the Cronbach's alpha [*27*].

In general, the correlations are medium to high considering reference values as defined by [*29*], considering a correlation satisfactorily, if the correlation coefficient is greater than 0.29. Only item 6.1 (0.2787), 7.2 (0.2537), 7.4 (0.199), 7.6 (0.1973), and 7.8 (0.2239) have an item-total correlation below 0.29, but with positive and not substantially low values. In addition, the value of Cronbach's alpha if the items were removed did not increase or did increase in a non-significant way.

The degree of correlation between the items determines the degree of convergent and discriminant validity. But, these results do not determine how many factors underlie the set of the questionnaire. With this objective, we performed a factor analysis, answering the analysis question AQ3.

AQ3: How do underlying factors influence the responses to the items of the questionnaire?

In order to identify the number of factors (quality factors or dimensions) that represents the responses of the set of the 38 items of the questionnaire, we performed a factor analysis. Based on the original definition of the questionnaire, we assume that it

is influenced by 4 groups of factors (perception about the university, student behavior, perception about program and perception about classes and faculty).

Prior to the extraction of the factors, several tests should be used to assess the suitability of the respondent data for factor analysis. These tests include Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity [*30*]. The KMO index measures the sampling adequacy with values between 0 and 1. An index value near 1.0 supports a factor analysis and anything less than 0.5 is probably not amenable to useful factor analysis [*31*]. The Bartlett's Test of Sphericity should be significant ($p < 0.05$) for factor analysis to be suitable [*30*]. Analyzing the set of items of the questionnaire, we obtained a KMO index of 0.7822471 and a significance level of 0.000, indicating that factor analysis is appropriate in this case.

To obtain the number of factors retained in the analysis, we used the Kaiser-Guttman criterion, because it is the most commonly used method. This method states that the number of factors is equal to the number of eigenvalues greater than 1 [*31*]. The eigenvalue refers to the value of the variance of all the items which is explained by a factor [29]. Following the Kaiser-Guttman criterion, our results show that 6 factors should be retained, explaining 59.65% of the data. The scree plot (Fig. 1) shows the eigenvalue for each factor number (representing each item).

We also use parallel analysis. In a parallel analysis, actual eigenvalues are compared with random order eigenvalues. Factors are retained when actual eigenvalues surpass randomly ordered eigenvalues [*30*].

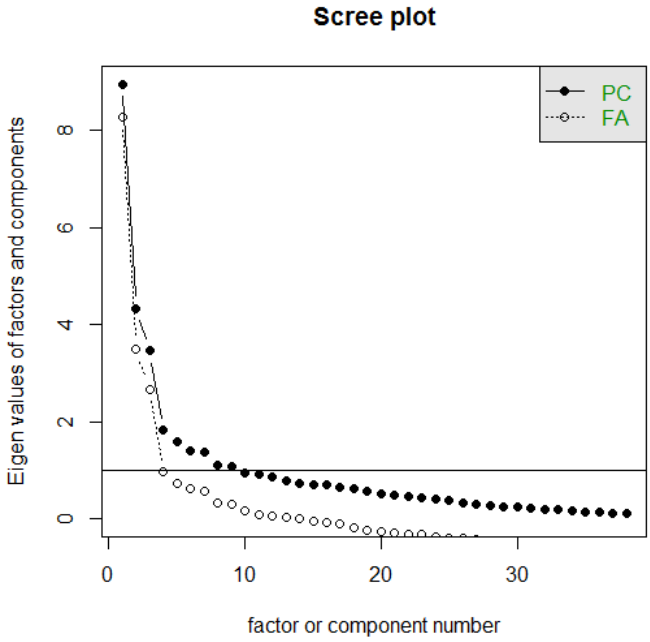

Fig. 1 – Factor analysis of adjusted questionnaire

Fig. 1 shows the scree plot considering the values of the principal components analysis and parallel analysis. Although the scree plot indicates 6 components above 1, the parallel analysis shows 3 or 4 factors. By comparing to the three alternatives (3, 4, 5 and 6 factors), the accumulated value is 39.5%, 43.3%, 46.1%, and 49%, respectively. However, by analyzing the graph of the factorial analysis, by using 6 factors we realize that the sixth factor has only one variable loading on it. Thus, this probably represents an over extraction and let's look at the five-factor solution. By using 5 factors we realize that the fifth factor has no variable. Because of this, the use of 4 factors seems to be more indicated.

After identifying the number of underlying factors, we determined which items are loaded into which factor. In order to identify the factor loadings of the items, we used the Varimax with Kaiser Normalization rotation method, because it is the most widely accepted and used rotation method [*29*].

Table VI shows the factor loadings of the items associated with the 4 retained factors. The highest factor loading of each item, indicating to which factor the item is most related, is marked in bold. The Chi-Square statistical test proves that 4 factors are sufficient (p-value = 0.000000708).

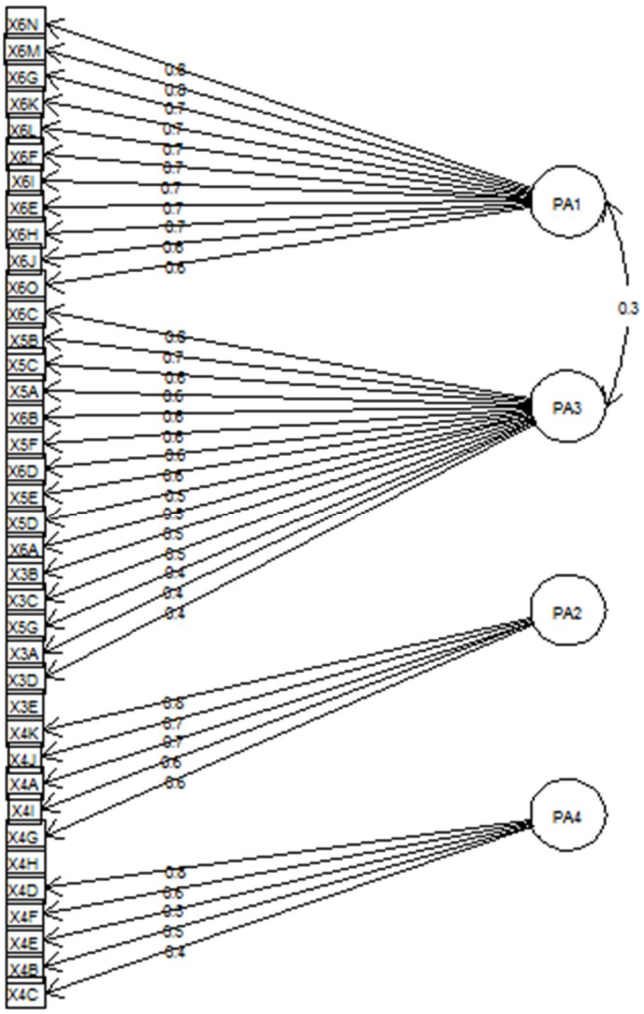

Fig. 2 – Factor analysis graph of the adjusted questionnaire

In this way, the four original factors are maintained, but there is a different distribution of the items in the groups. Factor 1 contemplates 12 items, all related to the group "perception of classes and faculty", related more to the behavior of teachers. Factor 2 brings together 16 items, being 7 related to the group "perception of the program", 5 related to the group "perception of the university" and 4 related to the group "perception of classes and faculty". These last 4 items are related to the student's learning experience. Factor 3 brings together 5 factors, all of which relate to "student behavior and engagement".

It is important to verify that these items are more related to individual behavior than with aspects of the interaction between colleagues and the university. Factor 4 includes the other 6 items related to the student's behavior and engagement group, and such items are related to student interaction with colleagues and the environment. Another important aspect is that two items (6.5 and 7.8) have no significant correlation with any factor. Fig. 2 shows a factor analysis graph of the adjusted questionnaire.

TABLE VI. FACTOR LOADINGS

	3A	3B	3C	3D	3E	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	5A	5B	5C
F1		0.112		0.147	0.134			0.128								0.147			
F2	**0.376**	**0.476**	**0.412**	**0.361**	**0.295**			0.237		0.199					0.119		**0.615**	**0.649**	**0.608**
F3					0.197	**0.608**	0.205	0.214		0.341	0.261	**0.559**	0.239	**0.592**	**0.777**	**0.853**			
F4				0.157		0.309	**0.529**	**0.444**	**0.722**	**0.601**	**0.623**	0.233	**0.281**	0.210	0.181		0.130		

	5D	5E	5F	5G	6A	6B	6C	6D	6E	6F	6G	6H	6I	6J	6K	6L	6M	6N	6O
F1	0.183	0.147	0.319	0.217	0.120			0.196	**0.709**	**0.678**	**0.750**	**0.676**	**0.698**	**0.620**	**0.719**	**0.698**	**0.749**	**0.758**	**0.569**
F2	**0.547**	**0.567**	**0.619**	**0.450**	**0.529**	**0.626**	**0.787**	**0.606**	0.250	0.211	0.363	0.309	0.222	0.310	0.129	0.155	0.116	-0.167	
F3			0.145	0.132		0.130											0.141	0.165	
F4				-0.209	0.100			0.108		0.204	0.110			-0.166	-0.139	0.103			

VII. DISCUSSION

Regarding the reliability of the questionnaire, we analyzed the internal consistency (AQ1). We verified that the value of the Cronbach coefficient is satisfactory (0.8904) for the questionnaire in general. We also calculated the internal consistency for each factor group, and only the "perception about university" group was slightly below the acceptable value (Cronbach's coefficient = 0.6503). We can conclude that questionnaire is consistent and reliable.

Regarding the validity of the constructors, in order to verify that the instrument actually measures the variables it wants to measure, we analyze the convergent and discriminatory validity (AQ2) by measuring the intercorrelation between the items and item-total. We have identified the tendency for the items of one-factor group to be correlated. Thus, indicating evidence of convergence validity. On the other hand, we found some correlations between items of different groups (16%), more frequently between items in the group related to the university and program (34%), as well as between program and teachers/classes (52%).

We also analyzed how the underlying factors influence responses in questionnaire items (AQ3), using factorial analysis and principal component analysis. By our analysis, the four groups of original factors must be maintained, but there is a different distribution of the items in the factors groups.

In this way, we understood that the questionnaire is coherent and presents an appropriate quality factor. However, some restructurings in the grouping of the items in the factors should be carried out in order to increase the validity of the constructors and ensure that the factors are measuring what they should measure. A suggestion of restructuring is: i) PA1 (faculty): grouping items related to teacher behavior; ii) PA2 (engagement): grouping items related to individual student behavior; iii) PA3 (educational structure): grouping university perceptions, program, and learning experience); and iv) PA4 (interaction): grouping items related to student interaction with colleagues and the university environment.

VIII. CONCLUSION

The results of the questionnaire application to identify motivating factors indicate that the instrument is acceptable in terms of reliability and validity. In terms of reliability, the alpha coefficient of Cronbach indicates the internal consistency of the questionnaire.

In terms of validity, the results indicate that the factors are measuring the desired variables, with a high correlation index between items in the same group. Although the results of the factorial analysis and the main components indicate that there are 4 main factors that impact the results, we identify that the grouping of the items in these 4 factors should be restructured. This indicates the need to reconfigure the questionnaire groups and items.

Despite suggested restructuring, the results indicate that the instrument is valid and can be used to measure factors that affect the motivation of computing students. In addition to being based on studies in the field of computing, it is based on factors that affect motivation, different from many existing motivational

scales. With this, researchers in the area will be able to use the instrument to carry out new studies in different contexts.

As future work, we intend to change the instrument according to the analysis of this work and apply it in new case studies to validate it again.

ACKNOWLEDGMENT

The authors would like to thank the Santa Catarina State University (UDESC) students who took part in this study and to the Department of Software Engineering at the same university that allowed us to conduct this study. We also would like to thank the support of the Postgraduate Program in Computer Science (PPGCC) of Federal University of Santa Catarina (UFSC).

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