Study Attitudes and Behaviour of CS1 Students – Two Realities

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Abstract

Teaching basic programming in higher education is one of the great challenges of computing. Much effort has been dedicated to the research of new languages, tools and methodologies that may help reduce the failure rates. Furthermore, analysis of student's cognitive abilities and attitudes have been undertaken to identify relevant characteristics that help understand the variables associated to the encountered difficulties. This paper presents results obtained through the application of the IACHE inventory, a generic behaviour test for higher education, to introductory programming students in Brazil and in Portugal.

Keywords: POP-I.A. Learning to Program, POP-II.C. Working Practice, POP-V.B. Questionnaire

1. Introduction

Teaching basic programming in higher education is one of the great challenges of computing. Many students entering computing courses have their first contact with programming in these disciplines, and are faced with the need to develop a logical / algorithmic reasoning, learn about a new technology and acquire knowledge about a new language's syntax and semantics, in addition to dealing with their transition from high school to the university. It is not, therefore, a surprise that these disciplines have been responsible, globally, for a large number of failures and dropouts in computing courses (Denning, 2004).

The problem is not limited only to computer science programs, but expands to virtually all disciplines of programming, not matter in which academic program they appear (Jenkins, 2002). Learning to program is not trivial, especially because it requires the conscious exercise of many well-developed cognitive abilities and essential personal skills. Learning to program is associated with the use of abstraction for problem solving, requires both creativity and rationality, requires dedication, patience, persistence and motivation (Lahtinen, Ala-Mutko and Jaarvinen, 2005).

This paper presents data obtained from students of two programming courses, in Brazil and in Portugal, over several semesters. The data was obtained by the administration of the IACHE inventory to 72 students in Brazil and 258 in Portugal. The IACHE inventory was designed to evaluate attitudes and behaviour in higher education students. Even though these two countries share a common language and some history, and the content delivered in the introductory course is very similar, the realities inside the classroom are very distinct. We want to investigate if these differences are also reflected in the student's profile. In section 2 we discuss learning and motivation issues, and in section 3 the IACHE inventory is presented. In section 4 we will introduce the two realities, describing the overall class demographics and teaching approach. Section 5 contains the results and analysis of the data, ending with our conclusions in Section 6.

2. Learning Programming and Motivation Issues

Researching the best method to teach the disciplines of introductory programming has been the basis for many discussions between professionals and organizations like the ACM (Association for Computing Machinery) and IEEE (Institute of Electrical and Electronics Engineers, Inc) (Astrachan et al. 2005; Bailie et al 2003; Bruce, 2005; SIGCSE-members, 2005). Unfortunately, due to the complexity of the task, no satisfactory solution has been achieved. The variables are many, and several paths have been pursued, addressing the different components involved in the learning process: students, teachers, and curricula. Most of the proposals involve the choice of different programming languages and tools, and the application of different teaching methodologies.

Studies show that characteristics such as prior mathematical and science knowledge have shown correlation with student achievement (Byrne & Lyons, 2001; Chumra, 1998, Wilson & Shrock, 2001). However, it is believed that this correlation is related more to the mental processes that students must acquire in order to solve mathematical problems and laboratory experiments, which are the same or similar to those required for programming. Surprisingly, studies presented by Bennedsen and Caspersen (2006) conclude that there is no correlation between capacity for abstraction and learning of programming. Also previous experience in computing is not a factor, though it can contribute to better outcomes in introductory programming courses (Allert, 2004, Byrne & Lyons, 2001). On the other hand, demographic characteristics (ethnicity, age, gender) of students are not correlated with success in programming (Evans & Simkin, 1989).

Psychological variables related to the learning style of students have also been considered in these studies although its influence in introductory programming courses has been ambiguous. The study by Byrne and Lyons (2001), found no correlation between learning style and performance. Allert (2004) and Thomas, Ratcliffe, Woodbury and Jarman (2002), both using the Felder-Silverman Inventory, reported that reflective and verbal learners have better results in programming courses than active and visual students. These results align with Felder's remarks that the teaching of engineering tends to reflective, intuitive, verbal and sequential learning styles.

Complementary to the cognitive abilities, student self-regulation is highly important. According to Barry Zimmerman (1989), self-regulated learning involves the regulation of three general aspects of academic learning: self-regulation of *behavior* involves the active control of the various resources students have available to them, such as their time and their study environment; self-regulation of *motivation and affect* involves controlling and changing motivational beliefs such as self-efficacy and goal orientation, so that students can adapt to the demands of a course; and self-regulation of *cognition* involves the control of various cognitive strategies for learning, such as the use of deep processing strategies.

As mentioned before, self-efficacy may be influenced by the student’s motivation, affecting the student’s judgment of his or her ability to perform a task in a specific domain. In learning situations, self-efficacy influences the use of cognitive strategies while solving problems, the amount of effort expended, the type of coping strategies adopted, the level of persistence in the face of failure, and the ultimate performance outcomes (Bandura 1986).

3. The IACHE Survey

The Study Attitudes and Behavior Inventory (IACHE – in Portuguese “Inventário de Atitudes e Comportamentos Habituais de Estudo”) (Monteiro, Almeida & Vasconcelos, 2005) is an instrument developed by a Portuguese research group to help evaluate university student’s learning strategies, not only the style, but also general aspects.

IACHE is a generic behaviour test, independent of the subject, with which it should be possible to assess:

- If a learning methodology, may or may not meet a set of requirements on a subject;
- Report the existence of changes in attitude of students regarding their academic posture;
- Establish statistical parameters of a population, identifying the proportions of its cognitive, motivational, and behavioural dimensions.

It is a multidimensional inventory that integrates in its design three mains aspects: *behavioral* (actions, daily routines, time management and study materials), *affective-motivational* (commitment, interest, involvement and progress in the study) and *cognitive* (personal perceptions and attitudes or approaches to learning). Regarding the approaches to learning, the inventory contrasts between a superficial and a deep approach to learning, i.e., with emphasis on memorizing information versus a more significant learning and understanding, along with a more self-concept component, integrating expectations and causal attributions.

These cognitive, motivational and behavioural dimensions have been divided into five sub-scales:

1) Focus on comprehensive learning - using reflection and analysis in depth of content, which means more effort and time spent by the student in learning. Learning-centred understanding;

Question examples: "When a subject has a variety of perspectives, I try to establish the differences and similarities between them."; "I try to understand the meaning of the subjects I study."

2) Focus on reproductive learning - which demonstrates a tendency of students to spend only a minimal effort to learn. Learning is superficial, based on memorization and reproduction of contents;

Question examples: "I prefer teachers who go directly to the point without a lot of explanations.", "I forget most things I study after the test."

3) Involvement - tests the student's availability for study activities, and is primarily related to requirements of intrinsic motivation:

Question examples: "I insist on trying to understand things which initially seem difficult.", "Spend some of my free time reading about interesting topics discussed in class."

4) Organization - examines the evidence of structured activities and study. Focus on how the students organize and manage their study (time, materials, etc.)

Question examples: "I have a personal study time properly organized.", "I study in advance the subjects that will be discussed in class."

5) Perceptions of personal competence - self-concept, expectations, etc.

Question examples: "I can understand certain subjects only if someone explains them to me individually.", "Even when I study very rarely get good results."

The inventory is composed of 44 items, distributed in five dimensions. The items were at first presented in a five-point Likert format, depending on the degree of agreement of students. This scale was later modified to a six-point Likert scale. This modification was made to avoid the central tendency error, where a lot of students "take refuge" in the intermediate point. The factorial analysis and internal consistency of the items have shown satisfactory results (Cronbach's alphas between .80 and .86).

This inventory was administered to a group of freshmen students from the University of Minho (Monteiro, Vasconcelos & Almeida 2005). Most of the student sample came from engineering courses. The analysis correlates the results with their entrance grade and gender. The results showed that students with higher grades in high school obtain higher levels in items related to the comprehensive approach and to the personal perceptions related to positive scales on competency and academic achievement. Higher results on several sub-scales were verified for the female students, showing higher scores on the comprehensive approach and study involvement, as well as better organization of academic activities.

Another study analysed data from students of different programs at the University of Minho, and related them to the entrance grades and academic results from the first semester to identify a possible correlation between these variables (Vasconcelos, Almeida & Monteiro 2005). One of the programs analysed was Systems and Informatics engineering, with a sample of 42 students. The mean and standard deviation results obtained for the five dimensions were: Comprehensive learning (41.12; 7.76), Reproductive learning (28.19; 4.63), Involvement (29.81; 4.74), Organization (33.55; 5.98), Personal Perceptions (30.95; 6.33).

4. Brazil and Portugal, Two Realities

Brazil and Portugal share a common language and some history, and the content delivered in the introductory programming course is very similar, despite the realities inside the classroom in both countries being very distinct. The Federal University of Goiás, in Brazil, and the University of Coimbra, in Portugal, have changed, in the last few years, the way introductory programming courses have been historically taught in their institutions. The reasons that have led to these changes varied, and the approaches as well.

4.1. The University of Coimbra's Context

The increasing number of students in the university system has overwhelmed the traditional academic model. In a short time frame, academia has been overwhelmed with a large number of students, with little time to properly modify its working model and unprepared to meet this demand. A transformation of the academic model to fit the new reality is a necessity, but is a process that is under development, in which sometimes the nature of administrative reforms end up influencing the evolution of learning processes. In Europe, one of the most important recent events in this regard has been the evolution and adaptation of universities to the Bologna Process, which led to the creation of a European Higher Education Area (EHEA) with unified strategies and development goals (EHEA, 2010). Within this new reality, the University of Coimbra has adapted its programs to conform to Bologna since 2005 (Wächter 2004).

The number of students in the introductory disciplines of programming in the Bachelor's Degree in Engineering and Information Technology (LEI – in Portuguese Licenciatura em Engenharia Informática) Department of Informatics Engineering (DEI), in Faculty of Science and Technology, University of Coimbra (FCTUC) is usually very high (between 200 to 300 subscribers). There is no pre-requisite, which explains the high number of students enrolled in these disciplines. The heterogeneity of profiles on some of these disciplines is also another feature.

In 2005 a new first programming course called IPRP (in Portuguese Introdução a Programação e Resolução de Problemas) was proposed as a transition programming course. This programming course had the aim of present the first programming concepts to the students under solving problems context using Phyton, as a way to reinforce the students problem solving skills.In Principles of Procedural Programming (PPP), for example, students may also come from the Bachelor of Industrial Engineering program (LEGI) or are remnants of the Bachelor's Degree in Communications and Multimedia (LCM), extinct in the 2008-2009 school year.

Nevertheless, the whole course is designed to fit the LEI students' profile. This is the second programming discipline of the course, aiming to support the basic knowledge of solving problems in programming acquired using Python in the first semester. The program includes basic programming knowledge for understanding the ANSI-C programming language (1999 standard), memory management, pointers, and algorithms for the fundamental data structures. Considering the size of the classes, the course is based on content presentation lectures and practical classes where the students can practice what they learned in the lectures, with evaluation points done using small practical programming challenges, made in pairs. As in other disciplines, the PPP classes are usually organized into:

- Lectures (02 hrs) - All students enrolled in PPP have class with a full professor responsible for the discipline;

- Practical sessions (02 hrs) - The class is divided into smaller groups in order to do hands-on lab exercises under the supervision of a teacher, who may or may not be the lecturer. Everything depends on the total number of enrolled students and the capacity of the laboratories. These groups have usually 20 to 30 students, with a total of 10 to 14 groups for each class and involve 3 to 4 other teachers, in addition to the full professor;
- Practice-Lab Sessions (02 hrs) - are not classes per se, but support sessions in which the students have study guides, reinforcements and clarification of doubts, with the aid of a tutor, usually a graduate student.

With the exception of practice-lab, that is not mandatory, all classes require advance registration and attendance, except from student-workers. Besides the classes, the activities developed during the course included: 10 exercise lists to be implemented in the practical sessions (with the appointment of some exercises to be presented orally), a theoretical evaluation, a mini-project (except for LEGI students) and a final exam at the end of the course. All activities are scored, and to achieve the minimum passing score the student must achieve a minimum of 10 points, in a 0-20 scale. To qualify for the final exam, the student must obtain a minimum frequency and grade, equivalent to 35% of the points attributed to the activities.

4.2. The Universidade Federal de Goiás' Context

In 2008, Problem-Based Learning (PBL) with tablet PC support was introduced in the discipline Computer Programming 1 of the Bachelor in Computer Science's program of the Informatics Institute (INF- Instituto de Informática) of the Federal University of Goiás (UFG) in Brazil to minimize the recurring problems of low outcome students, high dropout rates and lack of motivation (Ambrosio and Costa 2010).

In our classroom experience, we use the PBL method (Schmidt 1983) to introduce the concepts in the course syllabus as a series of open-ended problems, using a method adapted from Nuutila et al. (2005). Groups of four or five students work collaboratively to reach a solution to the proposed problems.

The description of a problem is given to each group, where for 40 minutes or so students discuss among themselves what are the possible ways to solve the problem, associating it with the knowledge they have and identifying topics that need more information or with which are not yet familiar, the so-called brainstorming stage. After this stage, students filter their ideas and the group identifies learning objectives that represent knowledge that must have to solve the problem and that must be researched /studied.

Outside the classroom, students work individually with the learning objectives, not being allowed the division of labor. Having obtained the necessary knowledge to solve the problem, students gather again to propose a joint solution, obtained from suggestions and individual solutions from each student. The resulting algorithm is then implemented. This process can take a week or more, depending on the complexity of the problem. Eventually the teacher can give a lecture addressing issues that were misunderstood by the students or to complement the learning objectives proposed by the groups.

The course is divided into two parts: the first using the only the SICAS environment, for flowchart diagramming, and the second the DevC++ environment. All basic programming concepts were discussed in the first phase, and again in the second phase. The first part extends for about a month and a half, while the second part lasts 3 ½ months. In each stage has several distinct problems are proposed. Examples of these problems include defining a calculator, and implementing games such as Battleship and Pac Man.

This discipline is offered in the first semester of the program, with a total of 64 hours in the classroom (32 encounters of 2 hours, twice a week). Attendance is mandatory. Students that miss more than 25% of the classes flunk the course. To be approved, the students must achieve a minimum of 5 points, in a 0-10 scale, to pass. These points are distributed among the activities of the course, and the teacher has autonomy to define the distribution. In the last years, the distribution that is being used is: 20% for individual participation in class and exercises, 20% for group solution of problems, 30% mid-term exam, 30% end-term exam.

The forty students that enter the program are divided into two groups of twenty, so that each student can have their own tablet PC. The laboratory used to teach the discipline is composed of four trapezoid-shaped tables with up to six students each. Each student is provided with a tablet PC with the necessary environments installed. Besides the full professors, one for each class, there is a monitor for each class, usually an undergraduate student, to help during class and in specified hours after class, with a weekly workload of 12 hours.

5. The Administration of IACHE

Analysis of data obtained from IACHE can provide some important information about the behaviour of students, individually and in groups, and shed light on some cognitive aspects of programming student's profile. The motivation for using IACHE was to make a comparative analysis of the profile of students in Brazil and Portugal, trying to identify similarities and dichotomies that can be used to guide the planning of changes in these disciplines.

The IACHE survey is divided into three parts, from which only the first one was considered for the analysis. It includes 44 statements. Groups of questions analyse each of the five cognitive dimensions whose answers vary in intensity from 1 (totally disagree) to 6 (totally agree). The score of each cognitive dimension is obtained by the sum of the answers to the questions for that dimension. The reference values and the average point for the comprehensive and organization focus are given by (1) and all other dimensions given by (2).

$$10 < \overline{X} < 60, \textit{ with } x_m = 35 \qquad (1)$$

$$8 < \overline{X} < 48, \textit{ with } x_m = 28 \qquad (2)$$

5.1. Brazil Results

The Computer Programming 1 course has 40 students per semester. Testing was done in 2009-2, 2010-1 and 2010-2, always at the end of the course. The sample is comprised of 72 subjects presented in Table I:

TABLE I
BRAZIL DATA SUMMARY

	N	Comprehensive		Reproductive		Personal Perception		Motivation		Organization		Age		Sex	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	F	M
2009/2	23	36,5	8,38	28,4	5,82	30,4	7,96	30,0	6,45	28,3	7,46	18,5	1,57	2	21
2010/1	31	40,1	6,68	30,7	5,84	35,5	5,00	35,5	6,90	37,4	9,96	18,5	2,15	1	30
2010/2	18	37,2	6,93	29,8	7,73	29,2	7,22	31,6	5,62	31,8	8,23	18,7	0,84	0	18
ALL	72	38,2	7,41	29,8	6,34	32,3	7,13	32,7	6,83	33,1	9,54	18,5	1,68	3	69

A non-parametric comparison of the cohorts was undertaken using the Kruskal-Wallis test. This showed a significant difference between the cohorts in the Personal Perception, Involvement and Organization dimensions (Table II, line 4). To further clarify these differences, a two-by-two analysis was undertaken using the Mann Whitney test (Table II, lines 1, 2, 3). Significant variances were observed between cohorts of the first and second semester for the same dimensions.

TABLE II
NO-PARAMETRIC TEST TO BRAZIL DATA SUMMARY

			I	II	III	IV	V
1	**2009-2 and 2010-1 (Mann-Whitney-U)**	**ρ-Value**	.132	.258	**.009**	**.003**	**.000**
2	**2009-2 and 2010-2 (Mann-Whitney-U)**	**ρ-Value**	.674	.580	.477	.664	.188
3	**2010-1 and 2010-2 (Mann-Whitney-U)**	**ρ-Value**	.124	.876	**.003**	**.029**	**.035**
4	**All students (Kruskal-Wallis)**	**ρ-Value**	.187	.567	**.003**	**.007**	**.001**

Comprehensive-I, Reproductive-II, Personal Perception-III, Involvement-IV, Organization-V

These results show that the cohorts differ in cognitive aspects not intrinsically related to programming, but in their self-regulated aspects. We believe these aspects are related to the profile and background of the students, more precisely with their self-efficacy beliefs, intrinsic motivation and coping strategies.

The verified differences between semesters may be explained by a characteristic of Brazil's selection procedures to the University. Admittance to a course is possible by passing a test called "vestibular". Students finishing high school take the test at the end of the year as to be able to start university in the beginning of the following year. Those that are not admitted, have a second chance in the middle of the year to start in the second semester. Thus, the students admitted for the second semester are usually less prepared than those admitted for the first semester. Furthermore, not all programs offer a second vestibular in the middle of the year, reducing the student's choice, leading to the selection of programs that may not be the students' first choice.

5.2. Portugal Results

In the 2008/2009-02 school year, the discipline PPP had 320 enrolled students, being 264 from the LEI program. The IACHE tests were applied between February (pretest) and July (post-test) of 2009. 118 students completed the pretest and 140 the posttest as shown in Tables III and IV.

TABLE III
PORTUGAL PRÉ-TEST DATA SUMMARY

	N							**Percentiles**		
Dimensions	**Valid**	**Missing**	**Mean**	**Median**	**Std. Deviation**	**Minimum**	**Maximum**	**25**	**50**	**75**
Comprehensive	118	0	38,8	38,0	6,40	23	54	35,0	38,0	43,0
Reproductive	118	0	29,2	29,0	5,14	18	43	26,0	29,0	32,3
Personal Perception	118	0	31,6	32,0	7,76	12	48	26,0	32,0	37,0
Motivation	118	0	30,6	30,5	6,21	11	45	27,0	30,5	35,0
Organization	118	0	30,5	29,5	7,65	11	48	26,0	29,5	34,3

TABLE IV
PORTUGAL POS-TEST DATA SUMMARY

	N							**Percentiles**		
Dimensions	**Valid**	**Missing**	**Mean**	**Median**	**Std. Deviation**	**Minimum**	**Maximum**	**25**	**50**	**75**
Comprehensive	140	0	37,6	37,0	7,21	22	55	33,0	37,0	42,0
Reproductive	140	0	28,1	29,0	5,44	15	39	24,0	29,0	32,0
Personal Perception	140	0	29,8	29,5	7,72	15	48	24,0	29,5	35,0
Motivation	140	0	29,9	30,0	6,93	10	45	25,0	30,0	35,0
Organization	140	0	29,2	29,0	7,49	12	52	24,0	29,0	34,0

For data analysis purposes, these were organized into three groups. It was possible to identify a matched sample consisting of 74 individuals, 50 individuals that did only the pre-test and 87 subjects that did only the post test. The results of nonparametric tests for the paired and independent samples are shown in Table V.

TABLE VI
NO-PARAMETRIC TEST SUMMARY

		I	II	III	IV	V
1	**Negative Ranks (Pos < Pre)**	45	50	40	39	46
2	**Positive Ranks (Pos > Pre)**	24	17	29	26	25
3	**Ties (Pos = Pre)**	5	7	5	9	3
4	**(Wilcoxon-W) ρ-Value**	**.014**	**.000**	.194	**.052**	**.004**
5	**(Mann-Whitney-U) ρ-Value**	.686	.452	**.040**	.952	.756

Comprehensive-I, Reproductive-II, Personal Perception-III, Involvement-IV, Organization-V

Observing the behavior of the independent sample (Table V line 5) and the related samples (Table V, lines 1-4), it is possible to conclude that the cognitive behavior of the two groups (independent sample) is very similar, differing not totally, but slightly, on the cognitive dimension of personal perceptions, where characteristics related to individuals' self-efficacy are observed. The 0.040 ρ-Value indicates that the level of confidence beliefs in the two groups differ, attested by reduced average between the pre-to post-test observed in Tables III and IV. This is a positive result, indicating that students' self-efficacy beliefs increased during the semester in the independent sample.

In the matched sample, the statistical evidence of differences between the two groups is clear for the Comprehensive and Reproductive dimensions, as well as for the Organization dimension (line 4 of Table V). The differences, however, cannot be considered positive, since the values of these three scores decreased from pre to post test. Except for the Reproductive approach, where low averages in this dimension is indicative of the students declined use of this type of learning strategy based on memorization of content, which is not very good for learning programming. However, the results do not indicate increased levels of the comprehensive approach, which means that while the students use less memorization tactics, they also do not override this behavior by the adoption of content deep learning strategies.

In the Personal Perception dimension, there is no evidence to classify the samples as different. In the Involvement / Motivation dimension, the 0.052 ρ-Value suggests a caveat, despite the decreasing means, it is not possible to state with absolute certainty, the existence of differences between groups, at the same time that it is not possible to declare the equality between them either.

It follows that, despite the homogeneous public within the discipline, the lessons' model and course program, did not represent a positive impact on the behavior exhibited by LEI students. Except for the result observed in the Personal Perception dimension of the independent sample, it is not possible to demonstrate, through test evidence, a positive impact of the classes' model in the cognitive status of the students during pre and post testing. Except for the slight decrease in the index of the Reproductive approach, all other indexes have proven negative for all cognitive dimensions, with the exception of the Personal Perception dimension which exhibited no change from pre to post test in paired samples.

6. CONCLUSIONS

In the traditional method of teaching programming, students hardly feel excited because they have to concentrate on coding and compiling problems generated by the rigidity of professional programming languages, in addition to solving the algorithmic problem. To tackle these problems different approaches have been defined, mostly with the use of new classroom methodologies and use of different programming languages and tools.

At the Federal University of Goiás, the Computer Science course adopted in 2008, the PBL method for teaching their CS1 course, along with the use of tablets PC and flowcharts. The results were quite satisfactory. Although there had been no significant increase in average scores compared to classes in previous years, there was a significant decrease in the number of failures and dropouts. However, there is still a 25% failure rate for the course.

The proposal used in Coimbra to adapt do the Bologna process aims to make students more independent and constructors of their own knowledge, returning teachers to their role of guiding students and in the journey of learning. Even though the idea is interesting, its implementation still has problems. With large classes and heterogeneity in the students' profile, there is a large dropout and failure rate.

To improve the CS1 outcomes, new solutions must take into account the student's profile, their attitudes towards learning and their acquiring of knowledge. A first step in this sense is to understand the students, and their profile. For this, we have applied the IACHE inventory that aims to identify the study attitudes and behaviour of undergraduate students.

The results obtained from the application of this inventory to students of a university in Brazil and another in Portugal, each with very different teaching approaches, allowed us to observe that the dimension that presents the more significant differences is the Personal Perception dimension. In the University of Coimbra, pre and post tests verified that the students' personal perception improved during the semester, while in UFG, the personal perception of the students in the second semester is lower than that of the first semester students. In the University of Coimbra, the other dimensions suffered a negative effect, demonstrating that the approach adopted for teaching introductory programming is not well suited.

Analysis of the means obtained for each dimension presented lower values for the University of Coimbra when compared to UFG. This was also true when comparing second semester UFG students with first semester students. The differences encountered may lead us to believe that these dimensions are in fact relevant to the success in programming courses. However, further and more detailed investigation is necessary to permit a deeper understanding of the causes and implications of these differences.

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