Student motivation towards learning to program

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Abstract— **This Research to Practice Full Paper presents a study on student's motivation towards learning to program. Motivation is a key factor in learning. Hence, stimulating student motivation strategies should be present in any pedagogical approach. This is particularly true in courses where a very active student attitude is fundamental. Introductory programming courses in higher education are a good example, which are known to be difficult for many students. To be successful students need to be motivated, as effort and commitment are necessary to overcome the difficulties many of them experience. In our study we analyzed several motivational aspects separately and then we correlated that information with the marks students obtained in introductory programming courses. We used two questionnaires. The Course Interest Survey (CIS) and the Instructional Materials Motivation Survey (IMMS). We could find some interesting correlations that confirm the importance of different motivational aspects to learning. We found other issues that demand more investigation, in order to create the best context to promote student motivation and learning.**

Keywords—introductory programming learning, motivation, students' perceptions.

I. Introduction

It is well documented in the literature that introductory programming courses put significant challenges to novice students and professors [1, 2]. In fact, anyone with experience of teaching such courses probably faced situations where students that could learn basic programming skills at a good pace coexisted in the same class with others that showed deep difficulties to make even basic progress. These difficulties frequently end in drop out or failure of a significant percentage of the enrolled student, creating several problems, including in the next courses where students are expected to be able to program.

The causes for this situation are certainly complex and diverse. We can find in the literature authors mentioning the inherent characteristics of programming as an important factor (abstraction level, problem solving skills involved, the complexity of programming languages constructs and syntaxes, among others) [3, 4, 5]. Teaching and learning conditions are also often mentioned by some authors (number of students per class, availability of enough motivated teaching staff that can really help students, inadequate pedagogical strategies used in the courses, and so on) [6, 7, 8]. Student's previous skills and attitudes towards programming learning are also often mentioned as a good part of the problem. Low problem-solving skills, inadequate study strategies, difficulties to understand what a program should do, and lack of commitment are commonly mentioned [9, 10, 11].

Of course, the causes for drop out and failure in programming courses are probably different for each student. However, for those students learning to program involves a significant amount of effort, as they need to intensively develop programs and for each program it is often necessary to identify and correct their own errors until a correct solution is found. To do that they need to believe that if they commit and make the necessary effort they may have success. In other words, this demands motivated and self-confident students.

Considering the above, we believe that student's motivation and self-perception of competence are key factors in learning. Consequently, we also believe that these factors must be considered in the design of any pedagogical strategy. This belief resulted also from several studies we made in the past.

In 2008 a first study [12] tried to correlate students' performance in an introductory programming course with some of their characteristics, namely previous programming experience, secondary education grades, learning styles, problem solving abilities and motivation to the study area. It was observed that all students that obtained high marks (>=16 points in a maximum of 20) showed a high level of intrinsic or extrinsic motivation.

Four years later, the results of another study that tried to connect students' study behaviors, attitudes and performance in introductory programming courses was published [13]. This study involved two Portuguese samples and used the IACHE questionnaire (a Portuguese acronym of Inventory of Usual Study Attitudes and Behaviors) [14]. The most important finding of this study was the strong correlation found between students learning performance and their personal perceptions of competence during the course.

One of our objectives was to make similar studies in a different context. That opportunity arose in 2016, when a study [15] involving a sample of Macanese students was developed. Two instruments (CIS - Course Interest Survey and IMMS - Instructional Materials Motivation Survey) that will be described below were used. Some differences were found, as the intrinsic motivation seems to be dominant for a higher percentage of Macanese students, when compared with their Portuguese

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colleagues. However, a clear correlation between motivation and performance in the introductory programming course could not be establish. Perhaps the high homogeneity of the marks obtained by the students can explain these results.

We decided to deepen our analysis and make another study in the academic year of 2017/2018. We chose the same context in Macao, involving a new cohort of novice computing students. This study is the main object of this paper. The remainder of this paper is structured as follows: section two presents a review of several studies that focus on the influence of student motivation in learning and on pedagogical strategies that may foster motivation; section three describes the ARCS model, the motivational theory underlying the instruments used in the study; section four presents the study, including a short description of the instruments and the main results achieved and, finally, section five includes the conclusions and some future research lines.

II. Related Work

It is possible to find in the literature several studies that focus on the influence of student motivation in learning and on pedagogical strategies that may foster motivation. Some of these studies are focused on student motivation in the context of programming courses.

Takemura and colleagues [16] analyzed factors that maintain or raise the motivation of art and digital design students to learn programming. The study involved students from two universities who were involved in courses that used the Processing language and environment. They found that the most important aspect was to use projects that allow students to see the program final result (artwork). This was even more important than the visual quality of the program results.

Carbone and colleagues [17] sought to identify the type of motivation that students demonstrated when they were working on programming tasks. They concluded that the ability to experience success seemed to promote students' intrinsic motivation. On the other hand, they also concluded that their good or bad experiences in programming tasks could strongly affect the novices' motivation, going from a state of intrinsic motivation to a state of demotivation and vice versa.

Yacob and colleagues [18] analyzed students' motivations when applying TQM (Total Quality Management) to programming learning using Problem-based learning through a web-based environment. The authors believe that constructive development through PBL and web-based programming learning tends to support cognitive development among novices. They state that there is a significant difference in terms of student's motivation after learning using the "TQM approach websites" compared to conventional approaches.

Velasco and colleagues [19] evaluated the motivation of students who were instructed under four pedagogical approaches: traditional lectures, collaborative learning, collaborative learning guided by CIF (an instructional framework for collaborative learning), and collaborative learning guided by CIF and supported by MoCAS (a collaborative learning tool). They considered the four dimensions of motivation according to the Self-Determination Theory [20]. Results suggest that the use of CIF and MoCAS is associated with high levels of intrinsic and extrinsic motivation, a finding that can aid in improving learning processes.

Many strategies and tools have been proposed to foster and maintain students' motivation during courses. Intelligent assistants [21], the use of motivational messages [22], robots [23, 24], videogames [25, 26], serious games [27], program animations or automatic evaluation of programs [28], among others [29], have been proposed trying to make the learning process more interesting for students.

Although there are several models with different assumptions and theories in this paper we used instruments based on the ARCS model. The next section is dedicated to some explanations about it.

III. The ARCS Model

The ARCS model was proposed by John M. Keller [30, 31], based on the expectancy-value theory, which derives from Tolman [32] and Lewin [33] theories. These theories can be applied in several areas and, although they may have different implications, the underlying main idea is that there are beliefs and expectations that affect human behavior. Therefore, motivation will be developed according to the expectancies (beliefs regarding the success on a certain task) and their correspondent value (subjective satisfaction task result).

The fundamental idea of this model is to create more efficient, effective and appealing educational experiences by taking into consideration four aspects that contribute to promote and maintain motivation in the learning process: Attention, Relevance, Confidence and Satisfaction [34, 35].

Attention concerns the interest shown by learners in learning a particular topic. The teacher should reflect on how a particular learning experience can be stimulating and interesting for the learners, in order to gain their attention [36]. First, the teacher should think about how to provoke students interest and then how to maintain it. Some suggestions consist in using surprises, novel or uncertain situations (perceptual arousal), stimulating the curiosity through challenging and problematic issues and questions (inquiry arousal), using a diversity of learning resources, methods, and strategies. It is particularly important to involve the students, in order to have an active participation, for example using strategies such as games, role playing activities and hands-on activities. It is also important that the teacher doesn't forget the eventual diversity of students learning preferences and use different materials (images, graphics, lectures, videos, group work and discussions) that may be useful for each of them in the explanation of each topic.

Having caught the learners' attention, it is necessary to show them the relevance of the topic. X The teacher should reflect on how he/she can provide a relevant learning experience for learners, so that they recognize the topic value and relevance [37]. For this, it is necessary to use concrete examples and establish analogies with what the student already knows, showing them the importance of the topic in the present and in the future. The teacher can use a set of strategies, such as allowing students to choose examples and/or projects that are relevant to them or inviting ex-students to give their testimony about the importance of the topic.

Confidence is related with the certainty of being able to handle a situation and reaching a goal. It is the student belief in his/her capacities and abilities to have a good performance and a good final result. Although, as previously mentioned, it is important for the teacher to launch challenges, these should not be too difficult, but rather have an adjusted degree of difficulty. It is important for students to feel that there are challenges, but that if they commit they will be able to surpass them. It is also important that the teacher gives a message of hope to the students and that their progresses are clearly recognized. The teacher should help the students to grow, organizing the learning process in small steps, providing them permanent feedback on their failures and achievements, but also giving space for learners to have some degree of control of their learning and to learn to self-regulate [38].

Satisfaction is a pleasant feeling that results from reaching some goal. It is important that the student obtain a sense of achievement and feel satisfied with that. It is important that the teacher promotes student satisfaction with their learning experiences, especially when they reach an objective. It is also important that the learning experience occurs in a pleasant and supportive environment, fostering student satisfaction. Feedback and reinforcement are important in this context but should not be excessive especially in easy tasks [39].

In our study, we used two instruments based on the ARCS model in our study. The Course Interest Survey (CIS) instrument is a multidimensional questionnaire that measures the motivational effect of course interest. It is based on 34 related questions (8 questions for Attention, 9 questions for Relevance, 8 questions for Confidence and other 9 questions for Satisfaction) [40]. The Instructional Materials Motivation Survey (IMMS) measures the motivational effect of instructional materials. It is based on 36 related questions (12 questions for Attention, 9 questions for Relevance, 9 questions for Confidence and 6 questions for Satisfaction) [40].

As situational instruments, the CIS and IMMS are not intended to measure students' generalized levels of motivation toward school learning. The goal with these instruments is to find out how motivated students are, were, or expect to be, by a particular course [40].

IV. The Study

The main goal of this study was to investigate the motivational levels of the students and to relate them with their performance in an introductory programming course. We analyzed several motivational aspects separately and then we correlated that information with the grades students obtained in the course.

The study involved a sample of students enrolled in the Bachelor of Science in Computing of the Public Administration School of the Macao Polytechnic Institute (MPI). The sample included 48 students, all male, aged between 17 to 24 years. The average and median age was 19 years, a usual age for students in the first year. The course used the Java programming language. It is important to note that these students have a very good entry level, resulting from the highly demanding entry criteria at the Macao Polytechnic Institute.

Each question of the questionnaires was answered through a 5 Likert-type scale. To calculate the final result for each student in a particular category we summed his scores to the individual items involved in that category, according to the instruments author classification.

We calculated the Cronbach's alpha of the instruments, reaching 0.811 for CIS and 0.838 for IMMS. This indicates a good internal consistency for both instruments. Analyzing separately each of the CIS dimensions/categories, the results indicated a good internal consistency: α=0.829 for Attention, α=0.827 for Relevance, α = 0.834 for Confidence, α=0.828 for Satisfaction. Similar calculations for IMMS also point to a good internal consistency: α=0.832 for Attention, α=0.808 for Relevance, α=0.816 for Confidence, α = 0.813 for Satisfaction. In the next sub-sections, we will present the results obtained with each instrument.

A. *CIS - Course Interest Survey*

As CIS has 34 questions the minimum point is 34, the maximum is 170 and the midpoint is 102. The overall results obtained considering our sample answers are presented in Fig. 1. In general, we can say that the motivation levels measured by this instrument were positive, as most students had a score above the midpoint. However, the results weren't very high, since most students had a total score not much higher than the midpoint.

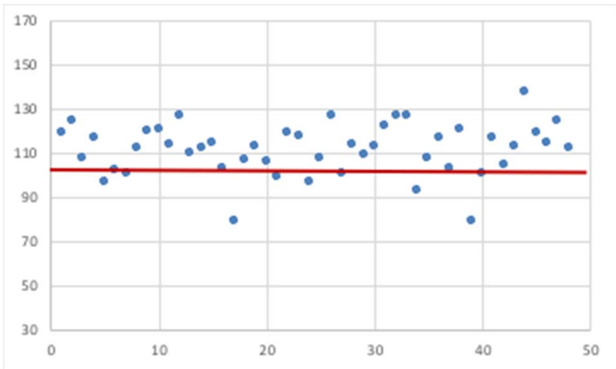

Fig. 1. General results obtained with CIS

Table I shows the descriptive statistics for each of the motivational aspects measured by CIS, considering all the students in the sample. Having in consideration the minimum and maximum possible results in each category, shown between parenthesis in the table, we can conclude that the average answer is above the midpoint for all categories, but far from the maximum possible score. The results for the categories Relevance, Confidence and Satisfaction are similar. The results for Attention are a bit lower. This may be a useful information for the course teachers, as in future editions they may try to address more specifically the aspects measured by this category.

TABLE I. DESCRIPTIVE STATISTIC OF THE CIS RESULTS

	N	Min.	Max.	Aver.	Stand. Dev.
Attention	48	15 (8)	30 (40)	25	4
Relevance	48	20 (9)	37 (45)	30	4
Confidence	48	21 (8)	35 (40)	27	3
Satisfaction	48	21 (9)	41 (45)	30	4

TABLE II. DESCRIPTIVE STATISTIC OF THE IMMS RESULTS

	N	Min.	Max.	Aver.	Stand. Dev.
Attention	48	26 (12)	50 (60)	38	5
Relevance	48	21 (9)	39 (45)	30	5
Confidence	48	21 (9)	43 (45)	30	4
Satisfaction	48	12 (6)	30 (30)	21	5

B. IMMS- Instructional Materials Motivation Survey

As IMMS includes 36 questions, the minimum overall score is 36, the maximum is 180 and the midpoint is 108. The global results obtained with the application of this instrument are represented in Fig. 2. We can consider that most students showed satisfactory motivation towards the used materials. However, in general the results are lower than those concerning the motivation towards the course (measured with CIS).

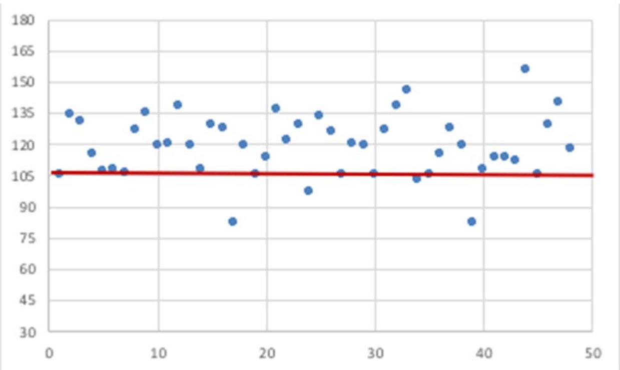

Fig. 2. General results obtained with IMMS

Table II shows the descriptive statistics for each of the aspects measured by IMMS, considering all the students in the sample. Considering the minimum and maximum possible results in each category indicated in the table, we can verify that the average results for all categories are higher than the corresponding midpoints. We can also observe that the dispersion of the IMMS categories results is higher than what happened with the CIS categories. Also, in the case of IMMS the category Attention presents average results below the remaining categories. Again, this information may be useful for the course teachers, as there seems to be some more room to improve the aspects measured by this category.

C. CIS and IMMS results relation

We wanted to know if the results in the different categories of the two instruments were correlated. The results are presented in Table III (CA, CR, CC and CS stand for the categories related with the Course and measured by CIS and MA, MR, MC and MS represent the categories related with the Materials and measured by IMMS).

TABLE III. CORRELATIONS BETWEEN THE CIS AND IMMS RESULTS

	CA	CR	CC	CS	MA	MR	MC	MS
CA	1	.923*	.920**	.877**	.931**	.823**	.797**	.757**
CR	.923**	1	.956**	.946**	.893**	.832**	.800**	.803**
CC	.920**	.956**	1	.937**	.907**	.815**	.819**	.782**
CS	.877**	.946**	.937**	1	.852**	.807**	.794**	.843**
MA	.931**	.893**	.907**	.852**	1	.811**	.837**	.704**
MR	.823**	.832**	.815**	.807**	.811**	1	.932**	.904**
MC	.797**	.800**	.819**	.794**	.837**	.932**	1	.834**
MS	.757**	.803**	.782**	.843**	.704**	.904**	.834**	1

It is possible to observe that all CIS categories are strongly correlated with each other, that is, the students who showed more attention were also the most confident to achieve success in the course and those who found it more relevant and as a result had higher levels of satisfaction.

All categories of IMMS are also strongly correlated with each other, meaning that the students more satisfied with the course materials were those that found them more relevant and reliable and, as a consequence, gave the materials more attention.

We could also find strong correlation between the results that concerned all the categories of both instruments. This means that the students that were more positive with the course were also those more positive with the course materials.

These results were expected and are coherent with the idea that the different aspects measured by the two instruments have influence in the student's opinions and behaviors. Positive or negative views about some course aspects tend to reflect positively or negatively in the remaining aspects.

D. Motivational Characterization

We also wanted to know which the dominant type of motivation in our sample was. We used the three types of motivation proposed by Jenkins, extrinsic, social and achievement (intrinsic) motivation [36]. A "null motivation" category was also included to accommodate cases not represented by the prior three categories. To evaluate this issue we asked the following question to the students: "Which of the following statements best describes your attitude towards the Computing degree: a) I want to do well for my own satisfaction; b) I want to do well to please my parents, family and friends; c) I want to do well to please my teacher; d) I want to do well so that I will get a good job; e) My main goal is to pass." Choice a) reflects the intrinsic motivation, choices b) and c) the social motivation, choice d) the extrinsic motivation and choice e) the null motivation. This same question had already been used in two previous studies [12, 15]. The answers are summarized in Table IV (the sum is higher than 100%, because the students could choose more than one answer).

TABLE IV. TYPES OF MOTIVATION

Extrinsic	29.17%
Social	4.16%
Achievement	50%
Null	16.67%

It is possible to conclude that intrinsic motivation was mentioned by half of the students, followed by extrinsic motivation that was important to about 29% of the students. Social motivation seemed to have little importance to our sample, while 16.67% choose the null motivation related answer.

We tried to find correlations between the type of motivation and the students' final marks in the introductory programming course. Even though no correlation could be established, an intuitive analysis shows that most students that had final marks higher than 75% gave answers compatible with intrinsic motivation. Also, almost all students that chose answer e) (null motivation) were among those who got lower marks in the course. All students with extrinsic and social motivation managed to pass the course but obtaining average marks. These results support the idea that intrinsically motivated students usually get better results. This calls our attention to the importance of promoting student motivation during the course, as a form to stimulate them to work harder and get better results.

E. Motivation and performance

It was particularly interesting for us to correlate the results obtained with CIS and IMMS with the grades the students got in the several assessment components of the introductory programming course. The assessment schema for the course consisted of one closed book test during the course which weights 20% of the final mark, a final closed book exam which weights 50% and open book exercises that jointly with the quality of the student's class participation correspond to 30% of the final grade.

We attempted to obtain correlations between the different categories of each motivational instrument and the three assessment components in the course, as well as the final result obtained. We found that all categories of both motivational instruments are strongly correlated with each assessment component, as shown in Table V. Also, all assessment components are strongly correlated with each other. This means that the most motivated students with the course and the materials had better marks in each assessment component and also in the final grade. These results reinforce the importance of motivation for learning and should be taken into consideration by teachers when devising their pedagogical strategies and their day-to-day interactions with the students.

TABLE V. CORRELATIONS BETWEEN CIS, IMMS AND ASSESSMENTS

	Exam	**Test**	**Exercises**	**Final Mark**
CA	.490**	.380**	.432**	.481**
CR	.538**	.412**	.484**	.530**
CC	.514**	.392**	.488**	.513**
CS	.609**	. 452**	. 497**	.585**
CTotal	.554**	.428**	.509**	.550**
MA	.435**	.391**	.444**	.459**
MR	.491**	.396**	.422**	.482**
MC	.402**	.316*	.390**	.407**
MS	.601**	.473**	.562**	.601**
MTotal	.507**	.411**	.464**	.507**
Exam	1	.769**	.801**	.953**
Tests	.769**	1	.847**	.901**
Exercise	.801**	.847**	1	.929**
Final Mark	.953**	.901**	.929**	1

We wanted to go deeper in the analysis of our data. In particular, it would be interesting to know if the categories assessed by the two instruments used (or some of them) could be seen as predictors of success in the course, measured by the students' final grades.

Table VI presents the multiple regression of the predictor variables (the eight categories CA, CR, CC, CS, MA, MR, MC, MS) on the student's performance in the introductory programming course. The multiple regression correlation coefficient (R) is 0.653. It shows the linear relationship between the predictor variables and the student's performance in introductory programing. The adjusted R square value is 0.309. This implies that the variation in the performance of students in the introductory programing accounting to the predictor variables is 30.9%

TABLE VI. MODEL SUMMARY

R	R Square	Adjusted R Square	Std. Error Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.653[a]	.427	.309	13.596	.427	3.633	8	39	.003

a. Predictors: (motivational variables: CA, CR, CC, CS, MA, MR, MC, MS)

Table VII shows the Multiple Regression ANOVA of the predictor variables on the student's performance in their introductory programming course. It produced an F-ratio=3.633, $p<0.05$. This means that there is a significant linear relationship between the predictor variables and the performance of students, measured by their final marks in the introductory programing course.

TABLE VII. ANOVA[A]

	Sum of Squares	df	Mean Square	F	Sig.
Regression	5372.964	8	671.621	3.633	.003[b]
Residual	7209.702	39	184.864		
Total	12582.667	47			

a. Dependent Variable: Final mark, b. Predictors: (motivational variables: CA, CR, CC, CS, MA, MR, MC, MS)

We also wanted to know which predictor variables had more impact on our sample performance in the course. Table VIII shows the relative effects of all predictor variables on student performance, in the order of absolute magnitudes, as indicated by standardized Beta (B) weights. When considering all the motivational variables together, the Confidence and Satisfaction on the materials showed a higher contribution to the performance, MC ($B = -0.493$; $t = -2.237$; $p < 0.05$) and MS ($B = 0.568$; $t = 2.194$; $p < 0.05$). The remaining predictor variables didn't produce a statistically significative impact in the performance, shown in Table VIII.

According to our data, MC category had a negative Beta weight, meaning that this variable had a negative effect on performance. Looking at the IMMS questions related to this category, we can see that probably some students got too confident in their abilities or thought that programming learning would be easier than the reality showed them. On the contrary, materials satisfaction variable (MS) had a positive Beta weight, meaning it had a strong positive relation with performance. Looking at the corresponding IMMS questions, we can conclude that course organization, the successful realization of course activities (mostly small programs development) and the quality of feedback received had a major impact in the student's performance in the course.

TABLE VIII. COEFICIENTS

	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
CA	-.552	.813	-.123	-.678	.502
CR	-.070	.884	-.016	-.079	.937
CC	-.084	1.006	-.015	-.084	.934
CS	1.111	.830	.285	1.337	.189
MA	.780	.552	.243	1.414	.165
MR	.212	.739	.082	.287	.776
MC	-1.321	.590	-.493	-2.237	.031
MS	1.680	.766	.568	2.194	.034

a. Dependent Variable: Final mark

We also found strong correlations between the different assessment components. This means that there weren't big changes in relative student performance among the three assessment moments. From a strict evaluation point of view, we could say that the course assessment scheme could be simplified without introducing big distortions in the final marks. However, assessment moments also have an important formative role. So, we cannot evaluate their importance only in terms of the final grade.

V. CONCLUSION

The main objective of this study was to see if some correlation could be established, using CIS and IMMS Instrument based on ARCS model, between students' motivation and their learning performance in an introductory programming course, measured by their grades in the course.

The study showed a positive correlation between students' learning performance and the several motivational parameters measured by the two instruments used. These results are consistent with other studies that state the importance of motivation in learning. As programming learning demands a lot of practical work (developing programs), including error finding and correction, motivation is probably even more important than in other areas. Novices often have to deal with the frustration of making errors that sometimes they don't understand. It is important that they believe that a higher level of commitment will lead to success and that the errors and frustrations are a natural part of the learning process.

Of course, teachers have an important role to take to support students, both in pedagogical and motivational terms. They should probably consider including measures to monitor and stimulate the students' motivation and confidence, making them clearly aware of the small learning improvements they produce (for example, making clear that the student now is able to solve problems that she/he couldn't solve some time ago). To make this possible it is very important that the teacher knows very well each student's programming abilities during the course and that a good teacher-student communication may be established.

Our results open the need for further research, namely on pedagogical strategies that may improve students' motivation, confidence and perceptions of competence, making them more willing to the effort involved in learning to program. Although some general recommendations were included in section III during the description of the ARCS model, we think that it is necessary to know more about student motivation and the effects that teachers' actions may have on it.

We plan to repeat the experiment in the next academic year, both in Portugal and Macao, and perhaps extending to other countries, trying to have bigger sample groups, so that we can achieve more reliable results. Knowledge about what affects, positively and negatively, programming learning is very important to define the best learning context and pedagogical strategies that may help most students to overcome the natural difficulties of learning to program.

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