

Studying Programming Students Motivation using Association Rules

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Abstract: For Programming teachers it is of utter most importance to understand the factors that impact on students' motivation to improve their ability to become good computer programmers. To understand a problem, to develop an algorithm for its solution, and to write the corresponding program is a challenging and arduous task, demanding time and self-confidence. In previous work we studied computer based technics to engage students in the learning activity; visualization, animation, automatic program assessment were some approaches that we combined. To support that work we studied carefully students' motivation and complemented that study with an inquiry to a group of students of Algorithm and Programming course of the first year of an Engineering degree. In this paper we show how Association Rules can be used to mine the data gathered in the inquiry to discover relationships among factors influencing extrinsic motivation.

1 INTRODUCTION

According to Hundhausen and Douglas (2000) or Proulx (2000) and many other authors, including the various notes included in the Computer Science Curricula of ACM/IEEE Guideline of 2013 (ACM/IEEE, 2013), confirmed by our professional experience teaching courses on introduction to computer programming, learn to program is an arduous and complex task that raises many challenges both to teachers and students. The lack of motivation is one of the main reasons for the students' failure in programming courses (Santos et al., 2006; Ramos, 2013). This has a direct impact on their ability to acquire knowledge and consequently affects the results of the teaching / learning process, which translates into a strong frustration for students and teachers. It is important to understand the causes of this disinterest, to combat them. In fact, there are several reasons why students fail to learn programming (Proulx, 2000); Faced with less difficulty in understanding the statement, in the development of an algorithm or in the use of a programming language, students become discouraged and give up (Tavares et al., 2017).

1.1 Objectives of the Study

Several theories have been developed to explain the motivation from the beginning of the history of psychology as a science. Because it is a complex phenomenon, the subject has been studied under different prisms (Williams et al., 2011; Almeida, 2012). Some of them claim that people are motivated by material rewards, others by increasing their power and prestige in the world, or by an interesting work, enriched environments, recognition, or to be respected as an individual. The fact is that humans in general have very complex needs and desires. Motivation is one of the keys to understand the human behaviour; it acts on the thought, attention, emotion and action of the Human Being, involving desire, effort, dreams and hope (Williams et al., 2011; Almeida, 2012).

People are driven by very different factors, with varied experiences and respective involvement. The motivation leads to an action directed to a particular goal, being regulated by biological or cognitive, factors of each person. This action is enabled by the needs, emotions, values, goals and personal expectations, constituting a single intentional and multifaceted phenomena (Ryan et al., 2000).

Motivate students is one of the biggest challenges that in general teachers have to face. In

programming courses (in the context of higher education institutions) this task is particularly difficult due to the skills needed and the complexity of the teaching topic; actually programming demands a new thinking paradigm and a high level of abstraction capabilities.

In order to assess the real difficulties, students feel in the teaching/learning process of programming, we have designed and conducted in our Engineering schools a survey which, in the first instance, was applied to 1st year students attending Programming, or Algorithms & Data Structures courses. This was applied to 160 students anonymously on the day of their exam; students were asked to answer with the utmost sincerity and without hesitation.

The work reported here, after the students' responses to an inquiry, aims to: understand the reasons for the real difficulties that arise in the teaching / learning process of Computer Programming and to study how these reasons are associated with Data Mining techniques in order to understand what kind of association rules could be inferred between the different factors and the motivation.

The paper is organized as follows. In Section 2 we provide a short background on Association Rules, our working tool. Then in Section 3 we discuss related concerning the application of Data Mining technics and tools to the analysis of educational phenomena. In Section 4 we review the basics on students motivation. Section 5 is the core of the paper: we discuss the application of Apriori algorithm to the data gathered from a motivation inquiry involving Programming Students in order to extract relations among factors that impact on motivation. Section 6 closes the paper.

2 ASSOCIATION RULES

In a dataset composed by binary variables V_1, V_2, \dots, V_n , it is often useful to find frequent associations between sets of these variables. These associations allow us to understand the interactions between any variables and can take the form of frequent set of positive co-occurrences of variables ($V_i = 1$, also called items) or association rule. An association rule has the form $A \Rightarrow B$ where A and B are frequent sets of items and expresses a tendency to observe B whenever we observe A . The confidence measure of a rule reflects the probability of observing B in a transaction of the dataset knowing that A is also observed in the same transaction. Confidence is

calculated empirically from the dataset itself and estimates the a posteriori probability of B . Another important measure that characterizes an association rule $A \Rightarrow B$ is the support that is defined as the proportion of transactions that simultaneously contain all items in A and B . Association rules are automatically discovered from a dataset using algorithms such as APRIORI (Agrawal et al., 1994) or FP-Growth (Han et al., 2004).

$$\text{Support} = (\text{freq}(A \cup B)) / N \quad (1)$$

Where N is the number of transactions in the dataset and $\text{freq}(S)$ represents the number of transactions that contain all the items in S .

$$\text{confidence} = (\text{freq}(A \cup B)) / (\text{freq}(A)) \quad (2)$$

Given minimal support and minimal confidence, these algorithms efficiently discover all rules with support and confidence equal to or above the required values. APRIORI works in two steps. In the first step it discovers all the frequent itemsets (with support at least equal to the minimum support) and in a second step extracts from these frequent itemsets the rules with sufficient confidence.

These algorithms easily produce a large number of rules, so other measures of interest of the rules, such as lift, conviction or Chi-square, are used in addition to confidence and support measures. In general, these measures determine to what extent the joint observation of antecedent and consequent happened by chance. The lift measure calculates the quotient between the a posteriori probability of the consequent of the rule and its a priori probability (Bayardo et al., 1999).

$$\text{Lift}(A \Rightarrow B) = \text{confidence}(A \Rightarrow B) / \text{support}(B) \quad (3)$$

When the lift value is close to 1, it means that A does not bring information about B and the rule is not interesting. Even if the rule has high support or confidence.

3 ASSOCIATION RULES IN EDUCATIONAL RESEARCH

Data mining uncovers hidden information from data and has been applied in a range of fields including educational research (Educational Data Mining) (Karkhanis et al., 2015; Mohamad et al., 2013).

Educational data mining can be a useful tool for helping teachers to modify their teaching strategies

and solve different educational problems and objectives. Association Rules mining is a widely used data mining technique. (García et.al, 2011; Ayala, 2014). In this paper we focus on the understanding of factors that may affect student's motivation. For that purpose, we use association rule mining. The Apriori algorithm is also used in educational data mining applications (Buldu et al., 2010; Abdullah et al., 2011; Kularbphetpong et al., 2012).

4 STUDENTS MOTIVATION

Resulting from the study that has been made, and published in the article (Tavares et al., 2017), we briefly recall in this section the basic concepts on student motivation.

For the teacher to play an important role in the learning process that occurs in the classroom, the teacher must have control over the external factors that influence the behaviour and involvement of students (Callahan, 2010). The level of motivation needed to involve each student in a given task is determined by his expectation for success and the value that the student gives to that particular task.

This theory suggests that students can succeed if they dedicate with effort and appreciate the activities in which they enrolled. As Almeida (2012) stated, it's important to understand why students do not have motivation. Many students attribute this problem to the behaviour of the teachers and the school in general, with the expectation that they are active elements in their learning. To verify this statement, we designed a questionnaire to survey students' actual opinion; as soon as we finish the analysis of the collected answers we will publish the study. On the other hand, the teacher assigns the difficulties to the students, with the expectation that they are interested, auto-regulated, with energy to search for knowledge, and responsible for their own motivation. In this way, there is a conflict between students' expectations, and teachers, who expect a general behaviour distinct from that, manifested by students (Almeida, 2012). The motivation is not only a unitary phenomenon, which refers to the concept of quantity. More than a lot of motivation, there are variations in levels and motivational guidelines. In this way, it is possible to ask what is the reason that leads to a more or less motivated behaviour. To reason about motivational quality it is crucial to consider the attitudes and goals that move people towards an action. A good example is the motivation that compels a student to do his homework. He can

do it without any curiosity or interest, simply looking for the approval of the teacher or parent; but, in the other way around, he can be motivated to acquire new knowledge, or face new challenges because he understands that his attitude brings advantage and values; or he can still be motivated because the knowledge acquired will give him a position to attain better grades or a better social life.

Motivation is like an impulse, a feeling that moves people to act to obtain their goals. Is what makes the individuals do their best, do what they can to get what they want. According to the theory of self-determination, the motivation can be intrinsic or extrinsic. The intrinsic motivation does not need any external factor. It derives from the student himself as the dedication, competence, willingness and ability to accomplish a task. Extrinsic motivation is the result of external factors, such as the resources that the student has, the rewards, and the environment where it develops his tasks (Silva et al., 2014). Both work together and the result will set the student's behaviour, as shown in the Figure 1 (Tavares et al., 2017).

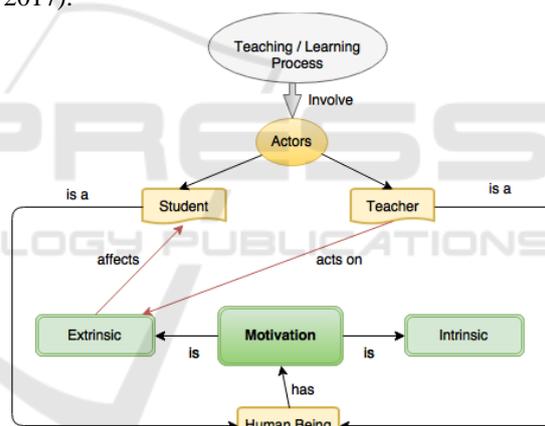


Figure 1: Student/Teacher and Motivation.

5 ASSESSING MOTIVATION

An experiment was conducted to assess the motivation of students in the process of learning programming. For that purpose, we have designed a survey (questions in appendix) and applied it to 237 first-year students of a Programming course from different institutions.

5.1 Using Association Rules

Besides conducting a descriptive statistical analysis of the data collected for the 237 students, we have

used Association Rule mining. A preliminary study using Apriori algorithm was carried out to understand what kind of associations could be inferred between the different driving factors and the motivation. We used the 'arules' package of R (a language and environment for statistical computing), with the parameters support = 0.1 and confidence = 0.9. These algorithms easily produce a huge number of discovered rules. To select strong rules that apply to at least 10% of the students and have a confidence close to one (Han et al., 2000). We used the lift interest measure in addition to confidence and support. We obtained a large set of association rules from which we selected some that are listed in Tab. 1.

Table 1: Results of some selected rules.

Discovered Rules	Measures
{Facing.difficulty.of.the.subject.I.feel.demotivated.and.I.give.up,Need.external.incentives} => {Feel.that.motivation.decreased.throughout.the.semester}	s=0.14 c=0.92 l=1.99
{Facing.difficulty.of.the.subject.I.feel.demotivated.and.I.give.up,I.would.like.to.be.able.to.use.an.exercise.support.platform.that.gives.feedback.shows.solutions.or.guides.resolution,Need.external.incentives}=> {Feel.that.motivation.decreased.throughout.the.semester}	s=0.14 c=0.91 l=1.98
{attribute.motivation.to.interest/challenge.of.the.subject,Don't.feel.demotivated.because.didn't.have.feedback.from.the.exercise.marking,The.main.reason.why.I.study.is.acquire.new.knowledge,Don't.feel.that.motivation.has.decreased.throughout.the.semester} => {feel.intrinsically.motivated.to.study.this.subject}	s=0.12 c=0.93 l=1.72
{attribute.motivation.to.the.importance.of.subject.for.professional.life,Don't.feel.demotivated.because.didn't.have.feedback.from.the.exercise.marking,The.main.reason.why.I.study.is.acquire.new.knowledge,feel.intrinsically.motivated.to.study.this.subject} => {Feel.that.motivation.don't.decreased.throughout.the.semester}	s=0.11 c=0.93 l=1.79

As we can see in Table 1, the difficulty of the subject and the need for support in the study seems to be related to the students' lack of motivation throughout the semester (0.92 of confidence). On the other hand, students who are aware that the subject may be useful for their professional life, who do not depend on feedback and who seek new knowledge seem to be more motivated to learn (0.93 of confidence).

In this case, the application of association rule mining to the student's survey data allowed us to

identify important factors that have an impact in the level and the dynamics of the motivation of the students throughout a semester.

5.2 Statistics

To assess the real difficulties that students feel in the teaching / learning process of programming, we elaborated a survey (in appendix) to 160 students of a first-year of programming course from one institution. Some of the questions asked and their results can be appreciated in Table 2.

Table 2: Percentage results of some questions asked to 160 students.

	Yes	No	Did not answer
Do you feel that your motivation has decreased throughout the semester?	45,6%	53,8%	0,6%
I have difficulty in understanding exactly what is intended by the exercises and test questions.	49,4%	50,0%	0,6%
I feel unmotivated because I do not have feedback from the exercise marking.	44,4%	55,6%	
I am in favor of the use of digital platforms for distance learning (eLearning), Moodle type or Blackboard.	90,6%	9,4%	
I would like to be able to use an exercise support platform that gives feedback, shows solutions or guides resolution out-of-class.	92,5%	5,6%	1,9%

Questions focused on student motivation: If it increased or decreased during the semester; if the student had difficulty solving the exercises; if the student need more feedback, if they have difficulty understanding what the question ask, among other questions.

It is observed (Table 2) that about 50% of students say they are discouraged during the semester. The same percentage says they cannot easily understand what they are asked to do. Also, a high percentage (about 45%) consider it to be demotivating due to the teacher's lack of feedback in good time.

In addition to these direct questions, it was asked whether the students felt intrinsically motivated to study the subject or if they needed external incentives, and found that 42% said they needed these incentives. This is a crucial result to justify the ongoing concern that the teacher has to find new and more effective ways to improve.

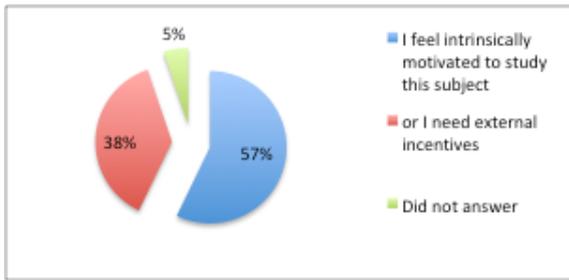


Figure 2: Percentage results to the question "I feel intrinsically to study this subjects or I need external incentives" of 160 students.

To the question "The main reason why I study", 48% answered that it would be to acquire new knowledge, 33% for good grades, which suggests that students need external rewards, notably grades, which is consistent with the results already shown in Figure 2. Through other questions, it was also possible to understand that students feel motivated due to the "interest / challenge of the subject" and to "importance of the contents for the professional life". The reasons chosen for their demotivation were the "difficulty of the subject" followed by a factor "mode of functioning of the classes".

To consolidate the previous study, a further 77 surveys were made to students from three different courses in different school years from two different Higher Education Institutions. The results corroborated the conclusions presented for the first sample, as can be seen in Table 3 and Figure 3.

After the conventional analysis of all the data collected for the 237 respondents, a preliminary study was made with Data Mining techniques in order to understand what kind of association rules could be inferred between the different factors and the motivation.

Table 3: Percentage results of some questions asked to 77 students.

	Yes	No	Did not answer
Do you feel that your motivation has decreased throughout the semester?	47%	51%	3%
I have difficulty in understanding exactly what is intended by the exercises and test questions.	53%	45%	1%
I feel unmotivated because I do not have feedback from the exercise marking.	35%	60%	5%
I am in favor of the use of digital platforms for distance learning (eLearning), Moodle type or Blackboard.	60%	39%	1%
I would like to be able to use an exercise support platform that gives feedback, shows solutions or guides resolution out-of-class.	87%	12%	1%

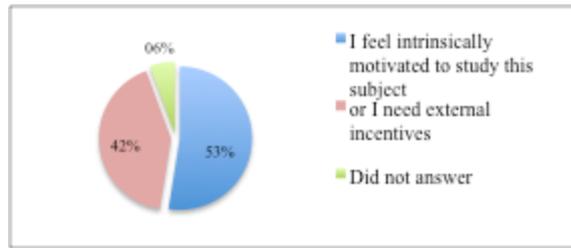


Figure 3: Percentage results to the question "I feel intrinsically to study this subjects or I need external incentives" of 77 students.

6 CONCLUSION

In the context of a project looking for computer-based strategies to aid on teaching/learning Programming, we started by identifying some factors that justify the difficulties felt by students that lead them to fail in the Programming Courses. Then we have studied the intrinsic and extrinsic factors that impact on the Humans' motivation. That research led us to proposed two approaches based on the combination of animation techniques with auto-evaluation systems to engaged students in the practical exercises of Programming courses aiming at the improvement of their learning. To assess the proposal some experiments were designed and conducted. In that context we decided to inquiry students about their own feelings concerning their motivation and behavior along those courses. This paper discussed the exploration, through the use of Association Rules, of the gathered data to quantify the relationship among the different parameters involved in our research hypothesis. The results extracted from that data analysis corroborate our assumptions: most of the students face big difficulties in the beginning of the course and as they are not intrinsically motivated for that area they gave up if they are not supported by immediate feedback and tools that make their engagement more fruitful and appealing.

In the future we will conduct more experiments, and collect more data concerned with students' feelings in order to apply again those Association Rules and other data mining approaches that will rigorously quantify our thesis about the ways we can increment students' motivation to learn more effectively the science of programming computers.

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APPENDIX

Please fill in this anonymous form in the context of a study about the difficulties in the teaching / learning process of Programming.
Please answer honestly and without hesitation.

<p>1 - If you feel motivated for this course, what factors do you attribute this motivation to:</p> <p><input type="checkbox"/> The interest / challenge of the subject</p> <p><input type="checkbox"/> How classes work</p> <p><input type="checkbox"/> The importance of subject to the grade</p> <p><input type="checkbox"/> The importance of the subject for professional life</p>	<p>2 - If you feel unmotivated for this course, what factors do you attribute to this demotivation:</p> <p><input type="checkbox"/> Difficulty of the subject</p> <p><input type="checkbox"/> How classes work</p> <p><input type="checkbox"/> Do not recognize the importance of subject</p> <p><input type="checkbox"/> Unattended due to lack of time or lack of knowledge</p>
<p>3 - Do you feel that your motivation has decreased throughout the semester?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>4 - Faced to the difficulty of the subjects of the course:</p> <p><input type="checkbox"/> I feel motivated to overcome them</p> <p><input type="checkbox"/> I feel unmotivated and give up</p>
<p>5 - The main reason why I study is:</p> <p><input type="checkbox"/> Acquire new knowledge</p> <p><input type="checkbox"/> Face challenges</p> <p><input type="checkbox"/> Obtain good grades</p> <p><input type="checkbox"/> To please others (teachers, family or colleagues)</p>	<p>6 - I have difficulty in understanding exactly what is intended by the exercises and test questions.</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>
<p>7 - I know how to value myself in the tests and works for evaluation (I know how to use time / effort).</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>8 - I feel unmotivated because I do not have feedback from the exercise marking.</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>
<p>9 - I feel intrinsically motivated to study this subject <input type="checkbox"/> or I need external incentives <input type="checkbox"/>.</p>	
<p>10 - I am in favor of the use of digital platforms for distance learning (eLearning), Moodle type or Blackboard.</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>11 - I would like to be able to use an exercise support platform that gives feedback, shows solutions or guides resolution out-of-class.</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>

Thank you!

