The Challenge of Learning to Program: motivation and achievement emotions in an eXtreme Apprenticeship experience

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Abstract

The importance of the education in informatics, also in non-vocational curricula, was recognized in the Italian school system many years ago. The introduction of the new discipline in a complex and articulated educational organization is still a work in development and its implementation may differ a lot across schools. Hence, computing background of bachelor students is really diverse. The teacher in this situation has to manage very different levels of skills and students often have to cope with failures and frustration. So, also motivation and emotions could have a role in determining performance. In this work, we present an early stage analysis of the connection between motivation, emotions and performance in initial learning of programming for bachelor students in Applied Mathematics in Verona. Performance in programming correlated positively with believes on control and negatively with anger and hopelessness. This finding supports the relevance of intervention programs promoting efficient motivational strategies and a positive emotional climate during learning of programming.

1. Introduction

Procedural methods of solving exercises are very common in primary and secondary school, particularly in scientific and technical disciplines. All the same, learning how to solve a problem in an algorithmic way and using a programming language is a non trivial task, even at the end of secondary school.

A course in programming requires fundamentals skills in the use of computers and assumes basic general notions about informatics. Many students have difficulties in thinking about problems in an algorithmic way: difficulties in understanding the problem and rigorously characterize it, problems in describing its solution informally, problem in coding it in a programming language (Wing, 2006), (Katai, 2015).

Some students reveal a lack of motivation, which is a relevant component of a successful learning activity (Jenkins, 2001). As matter of fact, in the secondary school with the word "informatics" people frequently refers to digital literacy or to the use of the information technology, rather than to computational or algorithmic thinking. Nevertheless, other scientific subjects, as mathematics or physics, may be seen as problematic and even abstruse, but hardly useless.

The role of motivation on learning outcomes is widely supported in educational psychology. However, a few number of empirical studies reported in the literature concerns computer programming courses. First year programming students in two university showed low level of intrinsic motivation (Jenkins, 2001). Students' learning motivation in learning programming seems to be connected with self-efficacy, which is demonstrated to be an antecedent of performance (Law, Lee, & Yu, 2010). The study assessed the relationship between motivation and self-efficacy, but did not actually observe performance. Kumar (Kumar, 2014), assessing affective learning - that is motivation, attitudes and emotions associate to a learning experience - connected to the use software tutors to learn programming concepts, showed that no differences in the level of affective learning was found considering sex, demographic group, and specificity of the major. Emotions seems to influence students' learning motivation, even if the effects of emotions on performance are complex, and more research is needed to disentangle the causal relationships of emotions with other variables inside a learning situation (Mega, Ronconi, & De Beni, 2014). The role of emotions in learning programming is not so highly studied yet, even if an attempt to understand emotional experience of learning to program is described by (Good, Rimmer, Harris, & Balaam, 2011). The authors underline the importance for the learner to assess emotions during the programming course experience, mainly because it increase emotional awareness. However, this study report qualitative data useful to understand students' feeling and thoughts concerning the use of this kind of assessment, and few information concerning the relationship between achievement emotions during learning experience and performance in the topic.

Control-value theory (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Pekrun & Perry, 2014; Raccanello, Brondino, & Pasini, 2014) defines achievement emotions as those emotions linked to learning activity or outcomes, differentiated for valence (positive and negative emotions) and activation (activating and deactivating emotions). This theory also considers some motivational antecedents of emotions, specifically people's beliefs concerning their control on the situation and the value they attribute to the task. The model considers the role of emotions, and of their motivational antecedents, in predicting performance.

The aim of this research is to investigate the relationships among motivation, emotions, and performance to better understand which factors can affect both students' emotions and performance.

2. Method

2.1. Participants

We consider students of the Bachelor program in *Applied Mathematics* enrolled at *University of Verona* attending the first year. The sample group consists of 64 students (49% males, mean age 20) enrolled in the first year. A subsample of these students was asked to fill in a self-report questionnaire on antecedents of achievement emotions and achievement emotions, and 18 students accept to participate (mean age was 20.3, 52.6% males). This subsample was used for this preliminary correlational analysis.

2.2. Teaching method

In the current academic year, we introduced a "light" version of *eXtreme Apprenticeship* (**XA**) in the practical part (Laboratory). This teaching methodology has been described in (Vihavainen, Paksula, & Luukkainen, 2011) for Programming in Finland and also in other contexts in Italy (Dodero & Di Cerbo, 2012), (Del Fatto, Dodero, & Lena, 2015), (Del Fatto, Dodero, & Gennari, 2015), (Del Fatto, Dodero, & Gennari, 2014). Its application in Verona is presented with more details in (Solitro, Zorzi, Pasini, & Brondino, 2016).

Extreme Apprenticeship is inspired to the *Cognitive Apprenticeship* (**CA**) learning model (Collins, Brown, & Holum, 1991). In CA the teacher gives students a conceptual model through the interactive presentation of working example. Then students solve exercises under the guidance of an experienced instructor; also they can receive hints to be able to discover the answers to their questions themselves. Finally they should be able to master tasks by themselves.

In the **XA** approach the hours devoted to frontal lessons are reduced. XA practical activities consist of a number of exercises of increasing difficulty that students have to solve actively interacting with the tutors and classmates. Suggestions are permitted, but no explicit or direct correction is allowed.

Programming exercises have also a positive impact on the motivational side (see, for example, (Brondino et al., 2015),(Bergin & Reilly, 2005).

In Verona we tried to applied these principle to our teaching, but we had to consider a working setting which is still "traditional": non continuous support by instructors, limited availability of laboratories, and other technical concerns. The acceptance of the new learning method was not compulsory; hence a group of students (1/3) decide for the traditional way of studying.

The rest of them (2/3) took part actively to a practical training in the initial stage (the first two months of the course). We asked the students to solve practical programming exercises of increasing difficulty at university or at home. A few issues come out: a lack in the comprehension of the requirements in a few cases; the basics of the language (`Python`) are generally good; the correctness of the solution is achieved at most in the 70% of cases.

Finally the students have taken a test divided in two parts: a general part on the fundamental notions of programming; a practical part with three exercises about: the comprehension of an algorithm; the definition of an algorithm starting from its formal characterization; the analysis of a simple problem and the definition of the solution. The practical part may contain suggestions, and the teacher can answer to a few questions on the textual interpretations of the exercises, but there is no support during the examination.

2.3. Measures

Motivation. *(Perceived control, task value, and self concept).* We assessed students' beliefs on perceived control, task value, and self concept with 12 self-report items. Items had to be rated on a 5-point *Likert scale* (1 = *not at all true of me* and 5 = *very true of me*). For perceived control (four items, *e.g.*, *I'm certain I can learn what we do in programming course*) and task value (four items, *e.g.*, *I think programming is useful for me to learn*), items were adapted from the Patterns of Adaptive Learning Scales, PALS (Midgley et al., 2000) and from Lichtenfeld and colleagues' work (Lichtenfeld, Pekrun, Stupnisky, Reiss, & Murayama, 2012). For self-concept (four items, *e.g.*, *I get good results in programming*), items were adapted from Goetz and colleagues' work (Goetz, Cronjaeger, Frenzel, Lüdtke, & Hall, 2010)

Achievement Emotions. We assessed 10 achievement emotions with the *Achievement Emotions Adjective List*, **AEAL** (Pekrun & Perry, 2014) (Raccanello et al., 2014), which consists of a list of 30 adjectives related to three positive activating emotions (*enjoyment, hope, pride*), two positive deactivating emotions (*relief, relaxation*), three negative activating emotions (*anxiety, shame, anger*), and two negative deactivating emotions (*boredom, hopelessness*). Items had to be rated on a 5-point *Likert scale* (1 = *not at all* and 5 = *completely*). Students were asked to evaluate how much they feel in that way related to attending the course.

Performance. Performance was operationalized in terms of the score obtained in the general theoretical part of the partial exam (*G_score*) and the score obtained in the exercises (*Ex_score*).

3. Results

Descriptive statistics. Analyzing students' performance on the two parts of the partial exams, considering the whole sample, we observed that the 70% of the students had a positive evaluation in the general part; in the three exercises students got respectively 73%, 62%, and 55%. Mean values and standard deviations of perceived emotions are shown in Table 1. The highest level is perceived for hope (3.3) and the lowest for shame (1.4). Positive emotions showed a higher average level than negative ones (positive: 2.96, $sd = .68$; negative: 2.00, $sd = .42$) and this difference is significant (paired sample *t-test*: $t(18) = 4.65$; $p < .001$) with a large effect size (*Cohen's d*: 1.1).

Relations among motivation, emotions and performance. Considering the subsample of students who participate to the assessment of affective constructs, we computed bivariate correlations among motivational antecedents, achievements emotions, and the two measures of performance (*G_score* and *Ex_score*). *G_score* was negatively correlated with one negative emotion, specifically boredom ($r = -.48, p < .05$). *G_score* was positively correlated with motivational antecedents, specifically perceived control ($r = .53, p < .05$) and self-concept ($.58, p < .05$). At the same time, *Ex_score* was negatively correlated with two negative emotions, specifically anger ($r = -.62, p < .01$) and hopelessness ($r = -.54, p < .05$).

Table 1 – Mean and Standard Deviation for each emotion (N = 19)

emotion	**valence**	**activation**	**mean**	**SD**
Enjoyment	positive	activating	3.0	0.8
Hope	positive	activating	3.3	0.73
Pride	positive	activating	3.1	0.83
Relief	positive	deactivating	2.6	0.76
Relaxation	positive	deactivating	2.9	0.95
Anxiety	negative	activating	2.5	0.69
Anger	negative	activating	2.0	0.74
Shame	negative	activating	1.4	0.52
Boredom	negative	deactivating	2.1	0.55
Hopelessness	negative	deactivating	2.0	0.63

4. Conclusion

Results concerning performance are encouraging, showing quite respectable performance, probably due to XA methodology (Solitro et al., 2016). However, we observed that a considerable part of the students decide to postpone the subject and give priority to more "traditional" subjects. This choice may be caused by low level of motivation and general learning overload. The higher level of positive emotions experienced by students in comparison with negative ones seems to highlight that XA methodology stimulates a positive affect, which in turn produces good results. To verify this hypothesis more research is needed, also comparing the XA methodology with traditional one, not only on performance but also on emotion undergone during the learning experience.

Looking at results on motivation and performance, this pilot study showed that students who perceived a high level of perceived control and self-concept, which are considered motivational constructs, had a better performance.

The results of the preliminary analysis on correlations among performance, emotions and motivation on this sub-sample of 18 participants were promising. Even if the sample is small, analyses underline the link between some emotions and performance, confirming that results reported by the literature are true also for programming courses. The relationship between anger, hopelessness and performance confirm that the more you feel angry and hopeless when attending the course, the worst is your performance (Pekrun et al., 2011).

An interesting result is the medium size negative correlation between boredom and performance; this means that, considering the general score, students who perceived high level of boredom, while attending the course, performed worse than students who perceived low level of boredom. Few researches concern the effect of boredom on academic performance, maybe because it looks like a "silent" emotion, not evident from the teacher’s perspective. Nevertheless, this result confirms some empirical evidence suggesting that lack of achievement values relate to boredom(Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010). Generally, empirical studies report a positive correlation between boredom, anger and hopelessness. Also in this pilot study these relations are confirmed (*boredom and anger*: .56; *boredom and hopelessness*: .45), and the model which connect these three emotion among them and with performance should be deeply explored.

These preliminary results highlight the importance to assess motivational antecedents and achievement emotions during the programming course, in order to help students to improve their performance, and, probably, to decrease dropout. A complete analysis of students performance, motivations and emotions will be possible only after the end of academic year.

A larger sample is needed to better understand the model of relations. For the future we plan a more systematic approach to the methodology and, if possible, a cooperation that also involves other universities.

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