Scaffolding Motivation and Metacognition in Learning Programming

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Abstract. This paper explores the role that feedback based on past actions and motivational states of the learner can have in a motivationally and metacognitively aware Intelligent Tutoring System (ITS) focused on programming.

Keywords. Motivation, metacognition, feedback, ITS, programming

Research Background and Work in Progress

Programming is regarded as a difficult skill to learn both by researchers and often by learners themselves [1, 2]. In turn it can have consequences on the learner's motivational state and metacognitive process. One overriding problem faced when learning to program relates to the learner's inability to combine various programming elements together to form/develop a program [2]. Spohrer and Soloway [3] recognise that learners are not given enough instruction on how to "put the pieces together", which relates to the underlying skills of problem solving, design and expressing the design through to the program solution.

Motivation and metacognition are key factors in the learning process. Research shows that motivated students enjoy higher levels of success and display better self-regulatory control [4], the outcomes of which can influence future motivation.. Reflecting and drawing upon prior knowledge and experience are important metacognitive activities that contribute to problem solving, but as mentioned in [5], "we seem to be very bad at recognizing that a problem we have just done can actually help us solve the problem we are currently attempting".

Two elements of learning that can greatly impact motivation and metacognition are the learner's *prior* experience and knowledge. An example of using the learner's past experience is the ELM-ART system [6], which displays, a past solution (sometimes the learner's own code) that closely matches the concepts of the current problem to provide a reminder to the learner. However the learner's past experience is not directly referenced in any feedback given by the system. In contrast Prime Climb [7, 8] is an educational game that uses the learner's *current* affective state to direct the pedagogical and affective actions of the agent (Merlin).

The aim of this research is to take ITS feedback a step further and create an ITS which aims to influence the learner's motivation and metacognition during the learning process. Guided by the past actions and motivational states of the learner, the ITS will provide three kinds of feedback; domain, motivational and metacognitive. In the scope of this research, domain feedback is assumed as a basic level of feedback that exists in

the ITS. The motivational feedback might be “do you remember how you felt when you solved task x? You achieved that without requiring a lot of help. Do you think you can do the same for this task?”. The metacognitive feedback might be “remember when you came across a similar problem in the previous task and the steps you carried out to solve it? Can the same steps be applied here?”.

The use of domain, motivational and metacognitive levels of feedback are intertwined and have a reciprocal relationship, as the intent of the surface content of the feedback given can be different to its impact. Using the metacognitive feedback example above, while the basic intent is metacognitive, it may also increase a learner’s motivational state and domain knowledge. It provides the learner with the opportunity to reflect on their past experience and draw upon their knowledge to work out how such previous steps can be applied to the current task, which also has the potential of increasing the learner’s domain knowledge.

An initial experiment was conducted with a single student using a kind of “Wizard of Oz” methodology, where the human tutor mimicked part of the motivational functionality of the proposed system, while an existing web-based system (ELM-ART) provided the “base level” interactivity. Where the feedback given by the human tutor was used, it had a positive effect in aiding the learner to answer the current question by providing them with an opportunity to form a link between past experience and the current question. It also promoted the learner’s sense of achievement at having derived the correct answer without having to be explicitly told the answer.

The proposed ITS will use a variety of sources to determine the learner’s motivational state; direct via self-reports and indirect via measures (e.g. use of help, degree of challenge, time spent). The ITS will also record the learner’s progress through tasks to aid the formulation of metacognitive feedback. The primary research will take the form of experiments that compare post-activity test results of learners who used an ITS with the feedback guided by past actions and motivational states, as opposed to students who used the ITS without such feedback. The process and behaviour of learners will also be observed throughout the duration of the experiments. The aim of the experiments will be to determine whether directly referring to the past actions and motivational states of a learner has an effect on their motivation and the metacognitive process by aiding the learner to learn from their experiences.

References

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