Examining the role of Self-Regulated Learning on Introductory Programming Performance

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Overview

- What is SRL? Why Study it?
- What SRL Components we analysed
- The research questions
- Methodology
- Results
- Discussion and Future Work

What is SRL?

- SRL is defined as the degree to which learners are metacognitively, motivationally and behaviorally active participants in their own academic learning
- A considerable number of studies have consistently found
  - a significant positive correlation between academic achievement and self-regulated learning
  - low self-regulating students are not as academically successful as high self-regulating students.
  - students who have high task value in a topic are more likely to use strategies to monitor and regulate their cognition than students with lower task value.
  - an intrinsic goal orientation is strongly positively correlated with the use of cognitive and metacognitive strategies and also with performance

Why study SRL?

- Over the past 30 years a considerable number of studies have taken place to determine factors that influence programming success
- Some studies have had interesting results but the area remains largely inconclusive
- Suggests that perhaps more evidence on potential factors needs to be gathered
- Computer science educational researchers have yet to examine, in detail, the role of SRL in learning to program
- The purpose of this study is to evaluate the relationship between SRL and learning to program and to determine if SRL can be used as a predictor of programming performance.

A Model of SRL

- A complete model of self-regulated learning should incorporate cognitive and metacognitive strategies, referred to as a `skill' component, and motivational components, referred to as `will' components
- Our study is based on a model of self-regulated learning developed by Pintrich and his colleagues
- The skill component includes cognitive, metacognitive and resource management strategies
- The will component is composed of various motivations, including intrinsic goal orientation and task value

Model components (1)

- Cognitive strategies include rehearsal, elaboration and organizational strategies
  - Rehearsal strategies include the recitation of information to be learned and mnemonic techniques for memory tasks
  - Elaboration strategies involve paraphrasing, summarizing, creating analogies and general note taking
  - Organizational strategies include clustering, outlining and selecting the main idea from text

Model components (2)

- Meta-cognitive strategies include planning, monitoring and regulating cognition:
  - Planning includes setting goals, skimming atext before reading and analyzing tasks
  - Monitoring includes tracking one's attention when reading or listening and self-testing using questions
  - Regulation concerns the continuousmodification of one's cognitive activities
- Resource management strategies refer to strategies students use to manage their time, effort, environment and other people

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Hypotheses (1)

1. *Students who perform well in programming will use more cognitive, metacognitive and resource management strategies than lower performing students*
2. *Students who have high intrinsic motivation will perform better in programming than students with lower intrinsic motivation levels*
3. *Students who have high intrinsic motivation will use more cognitive, metacognitive and resource management strategies than students with lower intrinsic motivation levels*

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Hypotheses (2)

4. *Students who have higher task value will perform better than students with lower task value*
5. *Students who have higher task value will use more cognitive, metacognitive and resource management strategies than students with lower task value.*

Finally, we intend to examine if SRL is a suitable factor for predicting performance on an introductory programming course.

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Methods

- The sample consisted of students enrolled in a third level introductory (object-oriented) programming module in 04/05 academic year
- The study was conducted in the first semester shortly after the students had started programming
- Forty students took the introductory programming module and thirty-five students agreed to participate in our study
- Continuous assessment scores used as measure of performance

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Instruments

- In this study we employed scales on the MSLQ that measure:
- The instrument used in this study was the `Motivated strategies for learning questionnaire' (MSLQ)
  - *Value Components:* intrinsic goal orientation and task value
  - *Cognitive Strategies*: rehearsal, elaboration and organization strategies
  - *Metacognitive Strategies*: planning,monitoring and regulating strategies and critical thinking
  - *Resource Management Strategies*: time and study environment strategies, effort regulation strategies, peer learning strategies and help seeking strategies

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Procedure

- An *a priori* analysis was carried out to verify no significant difference existed between the mean overall module scores of the class and the sample.
- Test assumptions on normality(Kolmogorov-Smirnov and Shapiro-Wilk) were confirmed.
- Cronbach's alphas for each of the MSLQ sub-scales in this study were calculated and verified for reliability.
- To test each of the hypotheses Pearson correlation coefficients and one-way ANOVA tests were prepared.

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Hypothesis 1

- *Students who perform well in programming will use more cognitive, metacognitive and resource management strategies than lower performing students*
- Significant pearson correlations were found between the use of metacognitive strategies and resource management strategies but not for the use of cognitive strategies with performance.
- Students were categorized according to their level of programming ability (high,medium and low)

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Hypothesis 1

- An ANOVA failed to reveal any statistical differences between the mean scores of students based on their use of cognitive strategies.
- A second ANOVA test did reveal a statistical difference between the mean scores of students based on use of metacognitive strategies *(F(2,31) = 6.127, p=0.006)*
- Subsequent analysis using Tukey HSD found that students with a high level of programming ability used more metacognitive strategies than students with low levels of programming ability

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Hypothesis 1

- A third ANOVA test revealed a difference between the mean scores of students based on their use of resource management strategies *(F(2,31) = 5.094, p=0.012)*
- Tukey HSD indicated that students with high levels of programming ability reported using more resource management strategies than students with low levels of programming ability.
- Our analysis partly supports hypothesis 1.
  - Usage of metacognitive and resource management strategies are important for programming performance while usage of cognitive strategies are not.

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Hypothesis 2

- *Students who have high intrinsic motivation will perform better in programming than students with lower intrinsic motivation levels*
- A significant Pearson correlation was found between the intrinsic motivation scale and programming performance, *r=0.53, p<0.01*
- Students were categorized according to their levels of intrinsic motivation (high, medium and low)

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Hypothesis 2

- An ANOVA test revealed significant differences between the mean programming scores of the groups *(F(2,31) = 4.161, p=0.025)*
- Tukey HSD revealed that students with high levels of intrinsic motivation had a statistically higher programming mean score than students with low levels of intrinsic motivation
- The evidence gathered supports hypothesis 2 that students with high intrinsic motivation perform better in programming than student with low intrinsic motivation

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Hypothesis 3

- *Students who have high intrinsic motivation will use more cognitive, metacognitive and resource management strategies than students with lower intrinsic motivation levels.*
- Significant Pearson correlations were found between responses to the intrinsic goal orientation scale and the use of cognitive, metacognitive and resource management strategies
- Students were categorized according to their level of intrinsic motivation (high,medium and low)

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Hypothesis 3

- An ANOVA test failed to reveal a difference in the use of cognitive strategies of students *However it did tend towards a significant difference , (F(2,31) = 3.055, p=0.062)*
- Further ANOVA tests did reveal significant differences on the use of metacognitive strategies *(F(2,31) = 17.69, p=0.00)* and resource management strategies (F(2,31) = 5.016,p=0.013) of students with different levels of motivation
- Tukey HSD found that highly intrinsically motivated students use more metacognitive strategies than students with medium and low levels of intrinsic motivation

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Hypothesis 3

- Also, highly intrinsically motivated students use more resource management strategies than students with low levels of intrinsic motivation.
- The findings partially support hypothesis 3. Students who have high intrinsic motivation use more metacognitive and resource management strategies than students with lower intrinsic motivation levels but there is no difference in cognitive strategy usage based on intrinsic motivation levels.

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Hypothesis 4

- *Students who have higher task value will perform better than students with lower task value*
- A significant Pearson correlation was found between the task value scale and programming performance *r=0.544, p<0.01*
- An ANOVA test found a statistical difference between the programming performance of students with different levels of task value *(F(2,31) =6.170, p=0.006)*
- Tukey HSD revealed that students with high levels of task value performed better than students with low task value. The findings support hypothesis 4.

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Hypothesis 5

- *Students who have higher task value will use more cognitive, metacognitive and resource management strategies than students with lower task value*
- Significant Pearson correlations were found between responses to the task value scale and the use of cognitive, metacognitive and resource management strategies
- Students were categorized according to their level of task value (high, medium or low)

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Hypothesis 5

- An ANOVA test failed to reveal a difference in the use of cognitive strategies of students categorized by level of task value, *however, the results did tend towards significant, (F(2,31) = 3.151, p=0.057*.
- An ANOVA test revealed a significant difference on the use of metacognitive strategies *(F(2,31) = 11.87, p=0.00)* and resource management strategies *(F(2,31) = 8.782, p=0.01)* of students categorized by task value
- Tukey HSD found that students with high levels of task value use more metacognitive strategies than students with medium levels of task value or low levels of task value.

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Hypothesis 5

- Furthermore, students with high task value and students with medium levels of task value use more resource management strategies than students with low task value
- The findings partially support hypothesis 5 Students who have high task value use more metacognitive and resource management strategies than students with lower task value levels but there is no difference in cognitive strategy usage based on task value levels

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Regression Analysis

- To investigate whether the various factors studied were predictive of performance on the module a number of regression models were developed.
- Model 1: consideration was given to the use of cognitive and metacognitive strategies. A significant model emerged with *F(1,32) =13.37, p<0.001* with an *adjusted R square = 27%*
- Model 2: considering the use of resource management strategies as well, resulted in a slightly more significant model, *F(1,32) =14.35, p<0.001* with an *adjusted R square = 29%*.

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Regression Analysis

- Model 3: Considering intrinsic goal orientation as well resulted in an *adjusted R square = 38%* with F(1,30)=11.066, p<0.001.
- Task value does not add any further weight to the models.
- Model 4: incorporating the scales within each of the categories (cognitive, metacognitive and resource management strategies) results in a regression model,with an *adjusted R square = 45%, F(1,32) = 14.281, p<0.001*

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Discussion

- The results of our study appear to at least partially support all of our hypotheses
- The finding that students who use high levels of metacognitive and resource management strategies achieve statistically higher results than students with lower levels of these strategies is consistent with previous research
- However, the finding that the use of cognitive strategies does not appear to relate to performance is interesting and warrants further research

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Discussion

- Perhaps strategies like rehearsal, elaboration and organization are not as useful in learning introductory object-oriented programming as they are in other other academic domains
- The result of this study that students with high levels of task value and intrinsic goal orientation use more self-regulating strategies and are more academically successful is consistent with results from other previous studies

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Discussion

- It appears that specifically designed tools that help students to self-regulate their learning and to encourage student's to develop an intrinsic goal orientation and higher task values would enable them to achieve higher results and to promote their SRL development
- However, while this study found a significant relationship between intrinsic motivation, task value and the use of various self-regulated learning strategies, it did not establish a causal explanation for the effects of these different motivational components on the use of learning strategies

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Discussion

- Further research is needed to try to determine the direction of this relationship before any solid recommendations can be made
- Finally, the predictive ability of SRL for programming performance is a useful contribution for research on factors that influence programming success.
- Combining SRL with other academic or non-academic factors that have already been shown to be predictive could facilitate the development of a more accurate model for predicting performance

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Limitations

- This study has a number of limitations
- As it was a once-off study, repeat studies using similar parameters are required to confirm the findings. To this end, the authors have undertaken to repeat this study at three other institutions
- The study measures involved self-report of behaviours. More data could be gathered e.g. think aloud, interview etc.
- In essence, the most significant contribution of this study is that it establishes that SRL does play a role in learning to program and, as such, it encourages further, more detailed, work in this area

Concluding remarks

- The present study focused on examining the relationship between SRL and performance in an introductory programming module.
- The results of this study indicate that SRL is important in learning how to program and can be used to partially predict performance onan introductory programming module
- The positive findings from this initial investigation warrant further research and provide suggestions for future related studies

All done.

- Thanks for your time
- Questions?