Self-regulated Learning Techniques for Engineering Students

William Alan Jowitt
AUT University, Auckland, New Zealand
ajowitt@aut.ac.nz

Ljiljana Jovanovic
AUT University, Auckland, New Zealand
ljovanov@aut.ac.nz

***Abstract**: One of the difficulties we face as Engineering educators is that of motivating students to take responsibility for their study. However, it is evident that students' learning increases as their willingness to accept responsibility for their learning.*

A current body of knowledge suggests that self regulated learning (SRL) techniques are beneficial in student academic performance. SRL is not something that lends itself to a precise definition but includes elements of cognition, metacognition and motivational theory. It is proposed here that a working knowledge of SRL techniques would assist students in many situations to enhance academic performance.

The challenge is to develop a set of processes which students may be taught in order to take responsibility for and enhance their learning. This paper defines some SRL techniques and describes a means by which students may be motivated to practise them.

Introduction

Several key questions were addressed in a study exploring student motivation in teaching and learning contexts (Pintrich, 2003). Two particular questions were of interest:

- What do students want?
- Do students know what they want?

In answer to the first question Pintrich (2003) lists three basic human needs, competence, autonomy and relatedness, assumed innate for all humans across all cultures in all situations and these needs are proposed as motivation factors. Pintrich includes a need for power and a desire to avoid failure as occasional influences on motivation. Hence it appears that students in general want competence, autonomy and relatedness (or affiliation) and in some cases want power and failure avoidance.

In response to the second question, Pintrich suggests that individuals do not need to know what they want in order for their motives or needs to influence them, and that goal pursuit may be nonconscious.

Pintrich (2003) predicts that understanding these matters will help educators in design of instruction. Just as engineers and architects may find different solutions to building or bridge design problems, creative and informed educators may develop a variety of useful instruction-design concepts to assist in motivating students

A survey carried out by the present authors on a group of students enrolled in the Thermodynamics and Heat Transfer paper in the Bachelor of Engineering Technology (Mechanical) programme at AUT University in May 2007 tended to suggest that a significant number of students do not know what they

want. Only one of 22 respondents quoted the reason for obtaining the qualification was to achieve entry into the Engineering profession.

Some respondents in the study claimed to have some background knowledge of the subject at hand. Analysis of the data showed that these students achieved better grades than others (hardly surprising) and that they showed some understanding that the qualification would enable them to "get a good job". An implication that may be drawn from the data is that a significant proportion of Engineering students do not have any concept of Engineering as a profession, or indeed what a profession is.

A further implication is that students with some background knowledge do at least have some idea of the opportunities that will be available to them after graduation. These students appeared more motivated than those with no background knowledge.

There is little doubt that the more students take responsibility for their own learning and go some way toward understanding how they learn, the more successful they will become in their studies and that higher student retention rates in universities will follow.

Self-regulation of cognition and behaviour is important in student learning and academic performance (Pintrich & De Groot, 1990). It is important that students are not only aware of self-regulation strategies, but are also motivated to use the strategies. In recent years the concept of self-regulated learnig (SRL) has evolved. Three essential components of SRL are proposed:

- Students' metacognitive strategies for planning, monitoring and modifying their cognition
- Students' management and control of their efforts
- Cognitive strategies that students use to learn, remember and understand course material

Further, SRL includes comprehension monitoring, goal setting, planning, effort management and persistence. Together these components can be taken as a working definition of SRL.

Pintrich and DeGroot (1990) considered links between SRL and individual student motivation. An adaptation of the so-called "general-expectancy model of motivation" was used for conceptualizing student motivation. The model proposes three components of motivation that may be linked to SRL. The three components are

- expectancy, which includes students' beliefs about their abilities to perform tasks
- value, which includes students' goals and beliefs about the importance of the tasks, and
- affect, which includes students' emotional reactions to tasks

The research carried out by Pintrich and DeGroot (1990) indicates that students who believe they are capable engage in more metacognition, use more cognitive strategies, and are more likely to persist with tasks than students who do not believe they are capable of performing tasks. Students who believe tasks are important, and who set out to achieve some mastery of the work are more likely to engage in SRL than students who do not have the same beliefs and objectives.

The study by Pintrich and DeGroot (1990) addressed three questions:

- How are the three motivational components related to SRL?
- What are the interactions among the three motivational components and their relation to SRL components?
- How are the motivational and SRL components related to student performance on classroom academic tasks?

Responses to the first question revealed that higher levels of self-efficacy and intrinsic value were related with higher levels of cognitive strategy use. Test anxiety was not associated with strategy use. Higher levels of self-efficacy and intrinsic value were correlated with higher levels of self regulation. Test anxiety was negatively correlated with self regulation.

The second question elicited responses that suggested prior achievement was a significant predictor of self regulation but not cognitive strategy use. Students achieving high grades were more likely to use self-regulatory strategies than were lower-achieving students but there was no obvious difference in cognitive strategy use. Students high in self-efficacy were more likely to use cognitive and self-regulatory strategies than were students who had low self-efficacy. Students high in intrinsic value were more likely to use cognitive strategies and to be self-regulating than were students low in intrinsic value.

The relationship between student performance, and motivational and cognitive variables, was indicated by the third question. Higher levels of self-efficacy and intrinsic value were associated with higher levels of student achievement. Higher levels of test anxiety were associated with lower performance in exams. Higher levels of self-regulation were associated with higher levels of achievement in all assignments.

Intrinsic value was strongly related to use of cognitive strategies and SRL, hence Pintrich and DeGroot (1990) suggest that it is important for educators to develop students' intrinsic value for their work. The object is not necessarily to lead students to obtaining higher grades, rather to result in more cognitive engagement in study.

The effects of SRL were investigated in a group of mathematics students in the Philippines. SRL techniques were taught to low-achieving mathematics students (the treatment group) during thirty sessions in a semester. A second group of low-achieving students (the no-treatment group) received no training in SRL. It was surmised that poor achievement was based on poor study habits (Camahalen, 2006).

The sessions were run in the "Mathematics SRL Programme". The study by Camahalen (2006) confirmed that students can become active agents of their own behaviours and can be trained to be responsible learners. The teacher's responsibility is to teach students how to learn.

Students showed significant improvement after 30 sessions of training. When taught to focus attention on processes and strategies that help to acquire knowledge and skills, students engage in activities they believe will help enhance learning e.g. exert effort and persistence. Students remember and learn more when using deep processing strategies, such as integrating information and monitoring comprehension.

At the end of the semester improvements in mathematical achievement in both groups was assessed. There were significant differences between the treatment and no-treatment groups. In the treatment group 60% to 100% of younger students showed improvement in three measures whilst among older students 100% showed improvement in all three measures.

During the programme it was observed among the treatment group that, as a student progresses, he gradually realizes his capability to do better. With improving performance interest in the subject increases and self-efficacy grows. The chain of events appeared to be cumulative.

In a project designed to explore the relationship between teachers' perceptions of student motivation and engagement, and teachers' enjoyment of and confidence in teaching, Andrew Martin described some elements (or dimensions) of motivation and related these to teachers' confidence and enjoyment in their work (Martin, 2006).

Strong links were identified between teachers' confidence, and student planning and persistence. Student inclination toward subject mastery was strongly enhanced by perceived teacher enjoyment of material.

Confidence is practically synonymous with self-efficacy, though self-efficacy is probably that part of confidence which gives the individual the belief that the individual can cope with whatever demands arise. Students with high levels of self-efficacy demonstrate abilities to

- Test alternatives when not initially successful
- Enhance functioning through effort and persistence
- Enhance ability to deal with problems by influencing cognitive and emotional processes.

There is an analogy between education and food. The student can not be force fed, but can be invited to the table to help himself. Educators need a mechanism with which to inspire motivation in students and to equip them with the beliefs that they have ability to perform tasks. It is assumed that terms relating to cognitive and metaconitive processes, intrinsic and extrinsic motivation, and various motivational theories are completely foreign to Engineering students. Thus a set of tools with which lecturers may persuade students to engage in SRL strategies is proposed.

Discussion

From the foregoing it may be concluded that student motivation is enhanced by

- Positive attitudes and enthusiasm shown by lecturers
- Increase in self-efficacy resulting from small increments in academic performance

Student motivation (especially at university) can be enhanced by effective communication. Motivation is seen to increase when educators

- Give clear messages to students about what is expected of them
- Explain how learning is structured and packed
- Give comprehensive feedback
- Clearly explain goals and assessments.

In order to build self-efficacy and induce some level of intrinsic motivation, and thus to improve academic performance in students, it is proposed that a structured approach to SRL be adopted by educators. To facilitate some understanding of SRL by the student body a set of tools is presented.

1. Self evaluation:

The student checks any work done to ascertain its correctness to the greatest extent possible. Frequently it is not possible to determine absolutely whether the work is correct before it is assessed, so it may be evaluated by:

- Checking that all given criteria are satisfied
- Consideration of mark value of assignment versus quantity and quality of work presented
- Discussion with peers

2. Organizing and transforming:

The student plans the work before starting. Transforming, especially in the context of essay-type assignments and reports, may include copying, then paraphrasing course material or material gleaned from other sources.

- Plan work
- Make outline of assignment
- Write then paraphrase material
- Incorporate own writing into outline

3. Goal-setting and planning:

Goals are generally short term, mostly fitting within with time frames from a minimum of few days to a maximum of one semester. Plans may be established for carrying out an assignment, preparing for a test or exam, or for an approach to an entire module.

A useful starting point is to make an overview of each module at the start of the semester. Breakdowns of mark allocations for each component of each module should be readily available from the course

information. The student may then assign priorities to assessments based upon which will contribute most to passing the course.

An essential component of planning is time management. A schedule for the whole semester may be prepared, showing all modules taken and dates of major assessments. A blank timetable showing days of the week and time segments within each day can be drafted.

Lecture times should be entered into the timetable. Time slots should then be allocated to essential activities and commitments (e.g. commuting, work, domestic chores, and recreational activities) with an allocation being made for resting. The balance of time available should then be allocated to study. A good starting point is to allow one hour study time for each hour of lectures.

Study periods should be scheduled so as to incorporate regular breaks for self review. The student should pause (say) every 30 minutes to reflect on the events of the previous half hour.

The review may be recorded in a tabular form, showing the type of work performed and how the student coped with the work. Some estimate of concentration (i.e. percentage of time spent actively engaged in the work) should be noted. Any distractions should be observed and attempts made to reduce or eliminate them in the future.

Planning, and adhering to the plan, comprise the most important part of SRL. Goals are generally short term, mostly fitting within with time frames from a minimum of few days to a maximum of one semester. Plans may be established for carrying out an assignment, preparing for a test or exam, or for an approach to an entire module.

The plan may comprise macro, micro and intermediate elements. For example at the macro level a useful starting point is to make an overview of each module at the start of the semester. Breakdowns of mark allocations for each component of each module should be readily available from the course information. The student may then assign priorities to assessments based upon which will contribute most to passing the course.

An intermediate element of the plan might comprise a blank timetable showing days of the week and time segments within each day. Lecture times should be entered into the timetable. Time slots should then be allocated to essential activities and commitments (e.g. commuting, work, domestic chores, and recreational activities) with an allocation being made for resting. The balance of time available should then be allocated to study. A good starting point is to allow one hour study time for each hour of lectures.

At the micro level plans may be devised for each assignment, and for each period of study. The study period should incorporate regular breaks for self review. The student should pause (say) every 30 minutes to reflect on the events of the previous half hour.

The plan for an assignment should list resources required, including computer access, software packages, texts, articles, notes, and writing and drawing instruments.

The review may be recorded in a tabular form, showing the type of work performed and how the student coped with the work. Some estimate of concentration (i.e. percentage of time spent actively engaged in the work) should be noted. Any distractions should be observed and attempts made to reduce or eliminate them in the future.

4. Seeking information

Check course information for prescribed and recommended texts. Determine whether texts cover topic adequately. If not, search library and or internet. Become familiar with information retrieval from library and or internet. Ask librarian for help, or enquire about library tours. Learn about searching databases, and hard copy and electronic journals.

5. Keeping records and monitoring

Keep notes of performances in each assessment. Record marks achieved against marks available. Note areas where poor marks scored *and* where good marks achieved. Make notes of items causing difficulty.

It is vital that students monitor their own learning progress because tertiary study provides very few opportunities for feedback compared to secondary study. During study time students should make regular (e.g. half hourly) evaluations of how they have performed. They need to monitor how they have spent the previous half hour, and make judgments about whether the time was productive.

It is helpful to keep a journal, with study time broken into 30-minute segments. The student can plot proposed activities ahead of time, then review how time was spent at the end of each segment.

6. Environmental structuring

Set up study environment conducive to preferred learning circumstances. Eliminate distractions such as television, computer games and telephones. Leave cell phones turned off in another room. Take an adequate supply of food and drink into the study room. Close curtains so as to prevent the temptation to look outside.

Arrange lighting so the work is well illuminated, without shadow, and bright lights are not directly visible. Maintain a supply of fresh air.

7. Self-consequences

Reward for good performance. When a major assessment is handed in on time, and or when a target mark is achieved. The target does not have to be 100%, a mere pass will suffice for a new student or one who has been failing. For future rewards set the target a little higher. Striving for continuous improvement (even in small increments) will eventually build self-efficacy. Rewards may include a treat such as a magazine, movie or just sharing success with someone.

8. Rehearsing and memorizing

May include recording and replaying lectures, reading aloud, and practicing computations. Procedures for solving mathematics-intensive problems may be learned by repetition.

9. Seeking social assistance

Seek help from friends, peers, parents and or faculty staff. Participation in study groups is beneficial.

10. Reviewing records

Students should regularly review marks obtained for assignments. Persistent low marks in a module should indicate that additional effort is required in that module.

Method of delivery

Many support programmes are offered during the week prior to a semester starting and are doomed to failure. It is not proposed to present SRL material in a single block, rather to spend a few minutes of lecture time at least once per week during the semester. Hence it is necessary to provide faculty staff with the SRL material along with instruction for its delivery.

The belief is that short, regular reminders when students are under pressure to complete assignments and prepare for exams is vastly more beneficial than a few handouts and lectures prior to commencing study.

Conclusion

Strong links between self-efficacy, motivation and academic performance are established. Deficiencies in these areas are often attributable to poor organization and inadequate study techniques on the part of learners. It is proposed that under-performing students will benefit from knowledge of SRL techniques, regularly revisited during the course of a semester. Further, it is suggested that, if these

techniques are learned during the first year at university, the process will become self-sustaining without the need for ongoing instruction for SRL and that students will become equipped for life-long learning experience.

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