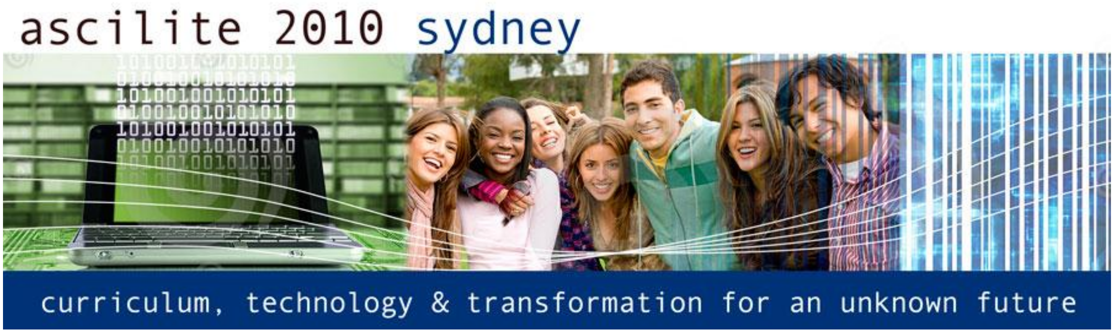

A case study on redesigning a mechanical engineering curriculum to promote self-directed learning

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This study investigates how the infusion of a self-directed learning approach impacts on learning, teaching and curriculum content. Segments of a traditional mechanical engineering module, Net Shape Engineering were redesigned to promote self-directed learning. Instructional strategies were selected to promote SDL processes such a self-management, self-monitoring and self-modification. Two of 3 lessons reported here were restructured using structured problem solving and compared with the traditional approach. Data was collected using SDLRS, questionnaires and MCQ scores. It was found that the instructional strategy promoted self-management, self-monitoring and self-modification. In addition, the approach promoted active learning through greater engagement and interaction. There was however a difference in student preferences for the two approaches. The Low SDLRS scorers liked the approach because they could be more involved in the learning and they felt it improved their understanding. On the other hand, Average SDLRS scorers preferred the traditional method because it saved time, was more structured, provided them with hardcopy notes and opportunities for copying notes. They also felt they did not have to go through the time consuming process of discovering answers for themselves or bring laptops to class

Keywords: self-directed learning, structured problems, autonomous processes

Background

Self-directed learning has featured in the educational reforms of many countries in the Asia Pacific region since the end of the last century (Mok and Cheng, 2005). Learners in the 21st century live in a strongly knowledge-based world economy which requires them to be independent, autonomous and lifelong learners (Day, 1999, Wong & Gerber, 2001).They are expected to be able to manage and keep up with the exponential growth of knowledge and of information and communication technology in the societies they live in.

In keeping with this global reform agenda, the Blue Ribbion Commission at the Nanyang Technological University has recommended as one of the key recommendations for educational reform at the university, the implementation of curricula that 'move away from teacher-led to self-directed learning' (BRC, Final Report, p19). The module chosen for this case study was a Mechanical Engineering course, Net Shape Manufacturing, MP4F07. The need to develop self-directed learning in engineering education (Stolk, J. et.al. 2009) has also been recognised to be vital for success in engineering environments and there seems to be a need for more research in this area.

This study was undertaken in the Division of Pedagogical Practice, Centre of Excellence in Learning and Teaching, Nanyang Technological University. The initiative recommended by the BRC required a move away from teacher-directed learning (TDL) to student-directed learning (SDL) and this would inevitably have an impact on the way students managed 'learning how to learn' and the way faculty manage 'teaching using the new pedagogy' in the university. As such, it was necessary to obtain research based information on how students responded to SDL and how faculty and curriculum content would be impacted when a transition is made for a TDL to SDL approach.

This study aims to understand how students respond to a more self-directed curriculum by investigating how a teaching strategy using the infusion of 'learn to learn' instruction in a content lesson impacts the learner, faculty and content of the curriculum taught

Literature review

The purpose of the following review is to (1) define self-directed learning and discuss the constructs involved, (2) differentiate between 'active SDL' and independent study, (3) discuss the rationale for choosing the instructional strategy used in the study, and (4) show how and why the instructional strategy differs from problem-based learning.

Definitions and assumptions about self-directed learning

Self-direction is generally understood as 'a process in which individuals take the initiative with or without the help of others, to diagnose their learning needs, formulate learning goals, identify resources for learning, select and implement learning strategies and evaluate learning outcomes (Knowles, 1975). Hiemstra's (1994) definition, 'any study form in which individuals have primary responsibility for planning, implementing, and even evaluating the effort' also emphasizes the 'process' element of the learning. This emphasis is important to this study as there is also a distinction in current literature made between 'active self-directed learning' which emphasizes decisions about aspects of the learning process and ' independent work' which refers to the extent to which the learner is challenged to use his or her mental abilities while learning (Simons, et. al. 2000). The definition used in this study is 'active self-directed learning' since the aim of the study is to investigate how students respond to SDL instruction that promote the use of autonomous learning skills.

A basic assumption made in this study about self-directed learning is that humans grow in capacity to be self-directing and learners can be more or less ready to take greater responsibility for learning (Knowles, 1995). Candy (1991) also viewed learner autonomy in learning processes as a continuum. Several studies have been conducted to measure readiness (Merriam, 2001) and scales such as the self-directed readiness scale (SDLRS) developed by Guglielmino (1997) are commonly used.

Two common reasons cited for student's lack of autonomy are their lack of independence and confidence (Brookfield, 1995). Moreover, it is not uncommon in the literature to find educators tasked with the responsibility to assist adults to learn in a way that enhances their capacity to function as self-directed learners (Mezirow, 198; Loyens, Magda & Rikers, 2008; O'Shea, 2003)

Facilitating Self-Directed Learning

In Hiemstra's (1994) Personality Responsibility Orientation (PRO) model, both internal and external aspects of self-direction are viewed on a continuum and it is said that optimal learning conditions exist for the development of self-direction when a learner's level of self-direction (internal) matches the extent to which self-directed learning opportunities (external) are available or possible. External factors include curricula and instructors that facilitate SDL and internal factors are factors that predispose the learner taking responsibility for learning.

Grow's (1991) Staged Self-Directed Learning Model (SSDL) reflects the same point that self-directed learning develops along a progression from dependency to self-direction and the roles of instructors should vary according to these differences. In addition Grow, Hiemestra (1994) and Spear and Mocker

(1984) argue the closer the match between the instructor's style and the learners level of readiness or self-direction, the more optimal are the conditions for the development of SDL.

The construct and skills for Self-Directed Learning

Song and Hill (2007) describe the main constructs for conceptual understanding of SDL developed by Candy (1991), Brockett and Hiemstra (1991) and Garrison (1997) and include a more comprehensive discussion of context in their model. The constructs for the study of SDL include (1) personal attributes, (2) processes, and (3) context.

'Personal attribute' includes learner characteristics such as motivation, prior knowledge about the content area, prior experience with the learning context among others. 'Context' in general includes various factors in the learning context that impact learner's experience of SDL. These are design elements such as nature of tasks, support coming from the instructor or peers. 'Process' which is the focus of this study refers to the learner's autonomous learning processes such as planning, monitoring and evaluating one's learning (Moore, 1972). These processes are described by Wolters (Simons, et. al., 2000) as competencies or skills required for 'active self-directed learning'. A self-directed learner is able to prepare for learning, execute learning and close learning. Planning, monitoring and evaluating ones learning are categorised as metacognitive functions or strategies that control, regulate and steer the other cognitive and affective functions involved in the learning process. The complete set of the taxonomy of learning strategies or functions used regularly and internationally have been compiled by Pintrich (1988). This study examines how instructional strategies infused in the curriculum promote students' skills for (1) planning –identifying what they already know and what they need to find out in the lesson, (2) monitoring **-** recognising what they don't know and knowing where they can look for answers to close learning gaps, and (3) evaluating – being able to determine if they have learnt what they need to.

Problem-based learning, self-direction and self-regulation

Problem–based learning (PBL) is widely used to promote self-directed learning. It is a commonly used instructional format to promote the development of students' learning processes or self-regulatory strategies such as planning, monitoring and evaluating learning (Winnie, 1995).

The choice of instructional strategy for this study has been influenced by the potential PBL has to promote SDL. The strategy used in this study however was modified and termed 'structured problem solving' for several reasons. The first reason has to do with how the instructional strategy is used in the study. The term SDL in PBL literature is defined as "preparedness of a student to engage in learning activities defined by him-or herself, rather than by the teacher' (Loyens, Rikers & Magda, 2008). This definition aligns well with the definition on independent learning defined earlier in this paper as 'extent to which the learner is challenged to use his or her mental abilities while learning' (Simons, et. al, 2000). This study however has adopted the definition 'active self-directed learning' instead as the aim of the study is to promote skills for SDL rather than provide opportunities for independent study.

The second reason has to do with the relationship between the process investigated and the definition of the construct used. The terms self-directed learning (SDL) and self-regulated learning (SRL) are distinguished in the PBL literature (Loyens, Rikers & Megda, 2008). The term SDL is used as an umbrella term in PBL while SRL is more concerned with the leaning process such as learning goals and strategies. In this study, SDL refers to 'active self-directed learning' and the construct investigated is the promotion of autonomous processes. Though the terms autonomous processes and self-regulatory processes seem to be synonymous, they will be kept distinct to maintain the distinction between 'active self-direction'and independent study used in this paper.

Research questions

The following are the research questions for this study:

1. Did the structured problem solving strategy promote greater use of autonomous learning skills required for SDL?
2. How did the students' perception of their role as learners change?
3. How did the students' perception of the role of faculty in teaching change?

4. Did the students like the new approach?
5. How did learner readiness impact their preference for self-directed learning?

Curriculum redesign: Infusion of structured problem solving to promote self-directed learning

The instructional strategy termed ‘structured-problem solving’ was used in this study to promote “learning to learn” or autonomous learning. It was used as a tool to facilitate planning, monitoring and evaluation (autonomous processes). Traditional lessons were restructured by breaking concepts down into sub-concepts with strategic questions to lead students to discover solutions. The structured problems were designed to ‘open’ students’ understanding of concepts taught. Instead of the traditional teacher-directed lecture where the faculty was an ‘information conveyer’, these structured problems were designed to facilitate autonomous learning by leading students into understanding concepts for themselves.

In order to study how students would respond to a more self-directed curriculum, selections of the lessons in the curriculum were restructured using a structured problem solving approach. This study reports on 2 of the 3 interventions which involve the infusion of the strategy (strategy 1) in the first intervention and a comparison of the traditional approach and the new one in the third intervention.

Intervention 1: Strategy 1 - structured problem solving & implementation

A regular lesson was restructured through the creation of nine (P01-P09) problems which evoked (1) recall of prior knowledge to solve the problem (self-management), (2) asking questions and seeking answers to obtain content/information to solve problem (self-monitoring), and (3) evaluating answers through matching with feedback on solution provided by faculty (self-modification) and assessing knowledge acquired at the end of the session by comparing with working of solution modelled for students (self-modification). Students at any stage learning through structured problem solving have the option here to go over materials where appropriate or seek further clarification to attain level of understanding they desire.

Students worked on each problem through the cycles mentioned above as they progressed through the nine sets systematically covering the content for the day. At the end of every problem, students volunteered their answers for feedback. Faculty discussed the solutions and provided input on learning gaps for them to understand the expected answers/working. The faculty summarized the key learning points at the end of the session and collected student’s solutions at the end of the session for any further feedback in the next session.

Snapshots of structured problem lesson with explanation of how it was done

The concept that the students need to grasp is the following: in sheet metal stamping operations the placement of the features to be stamped out are important to reduce the moment acting on the punch. In traditional lectures the concept is explained as mentioned in the statement and a sample problem calculation is used. The teaching of this concept was restructured into nine questions/problems that the students answer/solve in class. The nine questions and problems are explained below.

Self-Management: Recall of prior knowledge learnt in the same course (P01 and P02)
The students had to first recall some knowledge related to sheet metals (their definition, manufacturing and property variation) that they had just learnt in the past lectures.

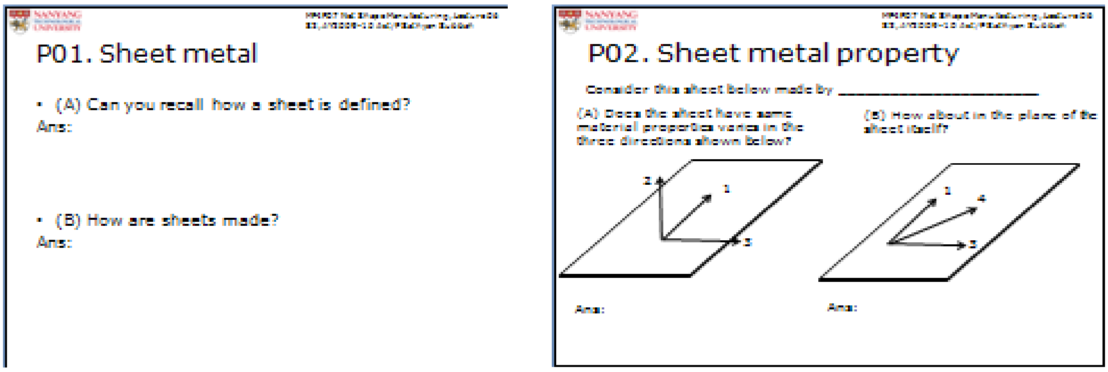

Figure 1: Recall of prior knowledge in the same course: sheet metal definitions and manufacturing, and anisotropic properties of sheet metal

Recall of prior knowledge learnt in same program but much earlier in year 2 of the program (P03)
The course being taught as a final year elective students had to recall some basic mechanics knowledge learnt in their second year. Here the students try and recall now to calculate the shearing force for a single feature to be punched out on the sheet, using their earlier knowledge of strength of materials.

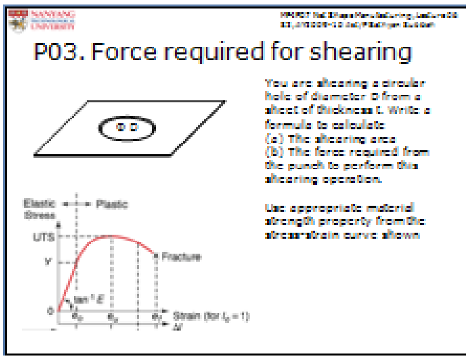

Figure 2: Recall of prior knowledge learned in year 2 of mechanical engineering program

Self-Monitoring: Visualization of forces acting on the punch and resultant force (P04 and P05) - single feature
The students are now required as a group to discuss and to visualize the forces that are acting on the punch by drawing the punch and the force distribution. By solving the problem together, students could monitor learning as well as ask questions while solving the problem. They could also refer to resources form databases and notes to locate answers to close learning gaps. They could also raise their hands to ask the faculty who was walking around as a facilitator. This drawing exercise makes them realize that the forces are actually distributed and that the resultant force is what they calculated earlier. The position of the resultant force, for this single feature, is rather intuitive and most of the students get this easily; later when the concept is extended to multiple features the students realize that this not so intuitive and one needs to make some calculations.

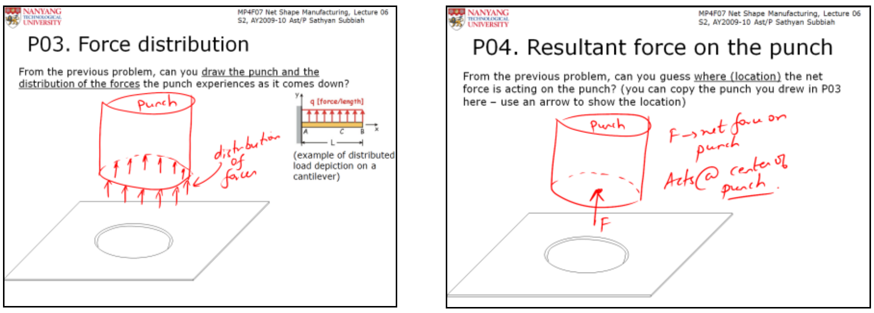

Figure 3: Visualisation - students have to draw the punch and force distributions and come up with the location of the resultant force

From single feature to multiple features (P06, P07, P08)
With the above lessons learnt the students now naturally try to extend to multiple features to be stamped out. The students visualise the punch in P06, estimate the shearing forces in P07 and draw the force distributions in P08.

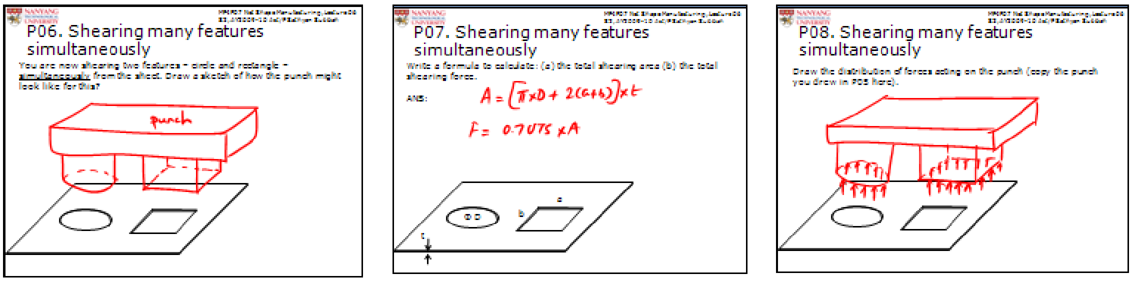

Figure 4: Extension to multiple features to be stamped out

Resultant force calculation for multiple features (P09 and sub parts a-f)
The question is now posed as to what is the location of the resultant force for multiple features. Most students were at a loss to intuitively answer this as they did in the single feature described earlier. The students are then walked through size sub-parts with more focused questions to lead them to the solution.

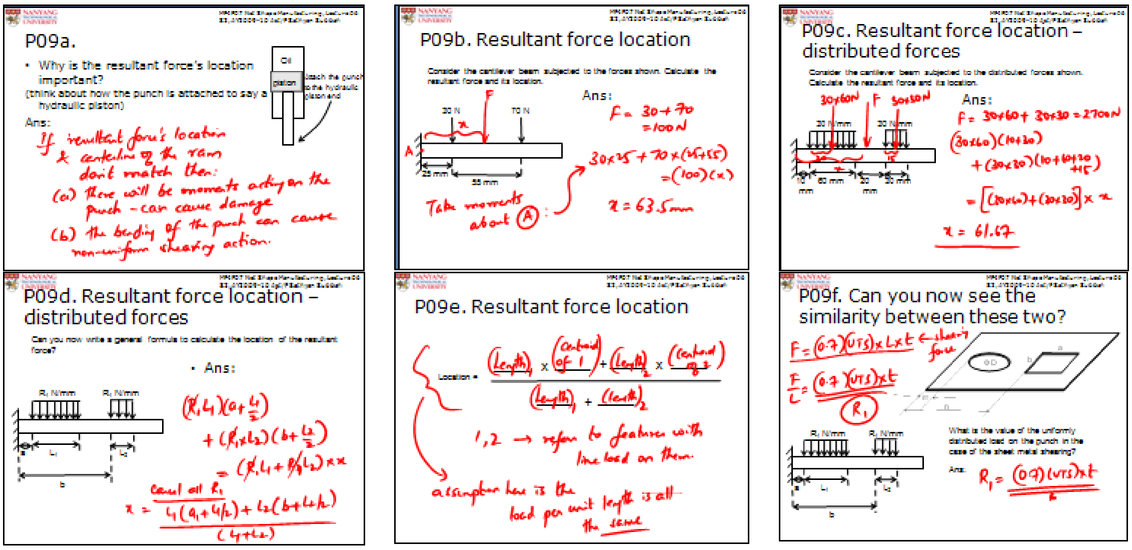

Figure 5: Prob 09, sub-parts a-f. Here the students learn to calculate the resultant force location and why it is important. They also come up with a general formula to calculate the location.

In the first sub-part (a), the students try to visualise and understand why the location of the resultant force is important. In P09b and P09c the students are made to recall a simple mechanics problem of resultant forces (point and distributed) acting on a simple cantilever beam. It was interesting to observe some students confusing concepts of reaction forces with resultant forces and going through the process of recall. In P09d and P09e the students try to come up with a general for a set of similar distributed forces acting on a cantilever beam. In P09f they try to see the analogy between what they saw in a cantilever beam and the actual sheet stamping process. Here they try and come up with an expression for the distributed force per unit length based on their earlier shearing force calculations in P03 and P07.

Once they have completed the nine problems, the class concludes by showing some examples of multiple feature shearing very common in sheet metal industries such as progressive dies.

Self-Modification: Evaluating answers and feedback
In order for the students to evaluate their own answers and provide feedback, some solved the above problem by implementing a free online office application provided by Google Docs. The slides were all uploaded into the web-based application. Each group of students opened their own copy of the slides and answered/solved the problems on the slides directly. A time limit was provided for each problem to

be solved, towards the end of which, the Faculty would ask for volunteer groups to display their answer on the overhead projector. Being web-based, the Faculty would then open that group's copy of the slides and discuss their answers and provide feedback.

Intervention 3: Comparing traditional and structured-problem solving approaches to develop skills for SDL

The faculty divided his lesson content into two segments in order to use structured problem solving and the traditional delivery mode to compare students' responses to the approaches. Pre-Post MCQ questions were also used to promote self-management, self-monitoring and self-modification of learning in both segments. The content validity of both sets of MCQ questions was ensured.

The content of the first segment of the lesson was restructured as described above. On the other hand, the content of the second segment of the lesson was conducted in the traditional lecture mode where faculty explained and taught with the help of power-point slides which contained blanks for students to fill answers and copy solutions being worked out.

The 2 sets of Pre- and Post- MCQ questions were designed to compare learning outcomes at the end of each approach as well as to provide additional support to evoke (1) managing learning by relating information in the notes and text from previous lessons to the new topic, (2) identifying what they did not know (ie learning gaps) and use the opportunity to ask questions to close these learning gaps; or use their initiative to find other means to seek an answer, and (3) evaluating if they had learnt what they needed to. The multiple choice questions were implemented on a web-based application via an online form that feeds into a spreadsheet file in Google Docs.

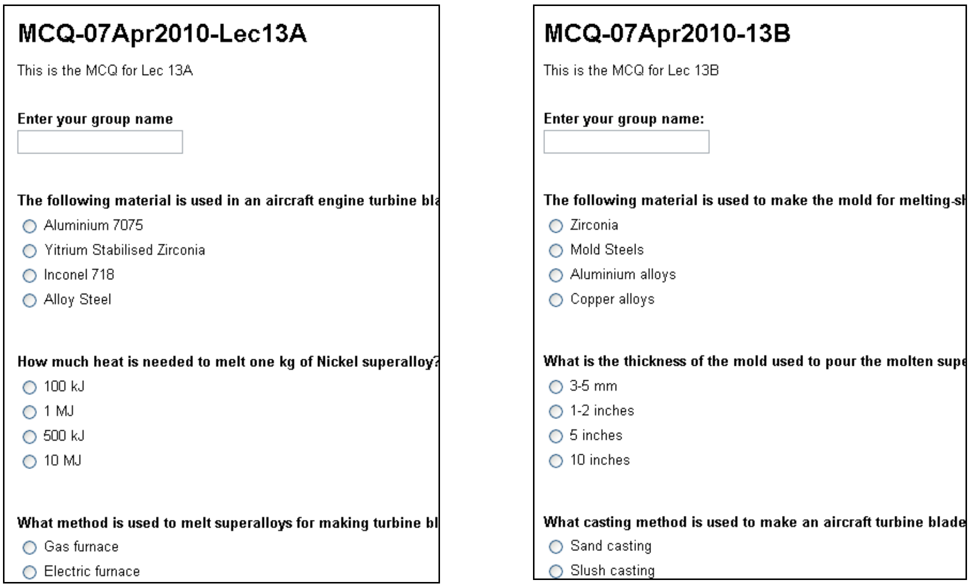

Figure 6: Snapshot of online MCQs for both traditional and problem-based lessons

This final intervention was conducted in the final week of the semester. As students by now had been exposed to two previous sessions of self-directed learning, they were asked to make comparisons of the two approaches with this experience behind them.

Methodology

Choice of instruments

The instruments used in this study were selected to provide data on (1) how autonomous processes such as planning, monitoring and evaluation were promoted in the learning approach introduced, (2) student's perception of the teaching and learning roles in the approach, (3) students' preferences for the new approach, (4) recommendations that could be made to promote greater effectiveness in the teaching /learning process when using the approach, (5) students' SDL readiness levels, and (6) how readiness impacted their response to the approach introduced.

Design of the questionnaire
Two sets of questionnaires were designed to collect information on areas mentioned above. The areas were identified from the constructs for SDL discussed in the Literature review. A total of 5 questions comprising a combination of semi-structured and 'Yes'/'No' questions were designed. In addition to questions relating to autonomous learning skills, questions to uncover students' beliefs about learning and teaching were also developed. This was necessary as students epistemological beliefs would help in providing greater understanding to how they responded to the new approach. Questions in the first questionnaire were modified to provide information required to compare the traditional with the structured problem approach.

SDLRS (version2008)
The adult version of the SDLRS questionnaire by Guglielmino (1997) containing 58 items was selected to provide information on student's readiness levels. The questionnaire was selected for its wide usage among researchers and because the types of questions asked related closely to the construct of SDL around which the questionnaires for this study were designed.

Pre- Post- Tests
The construct validity of the two sets of tests was ensured as discussed in the design section. The main purpose for these tests was to evoke autonomous learning at the start of the lesson and to compare learning outcomes at the end of the two approaches.

Administration of instruments and sampling

The first questionnaire was implemented online after strategy 1 was introduced in lesson 6 of the 13 week module. The second questionnaire was implemented face-to face in lesson 13 of the module after the two approaches were used in two halves of the same session. A hardcopy version of the SDLRS was also implemented at this time.

Sample
18 responses were received from a class of 30 students who attended the lesson for the first online questionnaire. 24 responses were received for the hardcopy version of the second questionnaire. 32 responses were received for the hardcopy version of the SDLRS.

All 18 responses were analysed and reported for questionnaire 1. For questionnaire 2 however, 14 responses are reported in this study. The students were selected because they attended all 3 intervention lessons for this module and provided feedback throughout the course by answering all 3 sets of questionnaires. This was a necessary criterion for students to be able to make valid comparisons of the strategies used in the study.

Data analysis

The data from the 10 questions extracted for the two questionnaires comprised single 'Yes'/'No' answers which were computed quantitatively and semi-structured questions which were subjected to a content analysis. The key descriptors from the content analysis were then categorised and grouped into themes. It was found that for some questions, the descriptors such as for 'roles of tutor' could be quantified into percentages because the answers were very specific and short. For questions that produced more descriptive responses, the themes were reflected in tables. For responses that did not answer the question, a 'Nil' response was computed. The pre-post- questionnaires were completed in groups and the results computed using Google Docs.

Findings

The findings reported in this section will discuss (a) how the use of structured problem solving impacted the learner, (b) the students' preferences when the traditional and new strategies were compared, and (c) how students' readiness for SDL impacts their learning preference for the two approaches.

The impact of structured problem solving strategy on promotion of skills for SDL

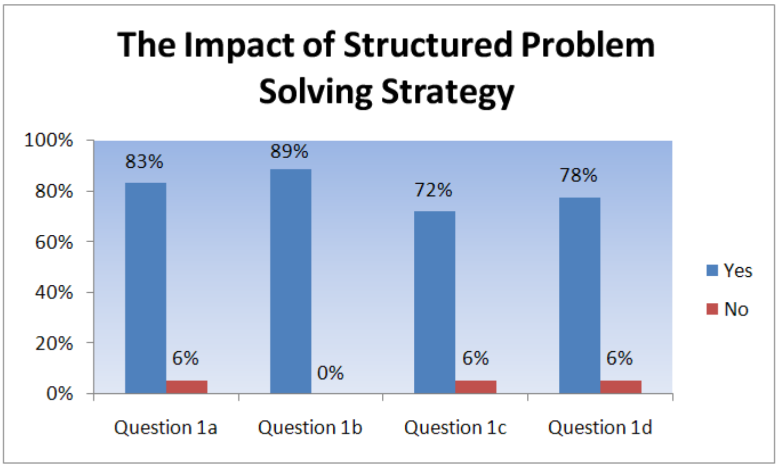

Figure 7: Impact of structured problem solving strategy on promotion of SDL

The data in Fig 7 (n=18) shows 83% of students indicated the approach evoked awareness of what students already knew about the content taught. 89% indicated it evoked awareness of what the students did not know and needed to find out. 72 % indicated it enhanced awareness of where they could obtain answers for themselves and 78% indicated the approach enhanced awareness of whether they had learnt what they needed to.

The data suggests structured problem-solving as a strategy to teach content promotes the use of autonomous process skills required for self-directed learning among students. The higher percentages for the planning and monitoring skills (1a & b) suggests students may need more help locating resources (1c) to solve problems and close knowledge gaps as well as evaluating (1d) if they have learnt what was expected of them.

The impact of structured problem solving on faculty's role in teaching

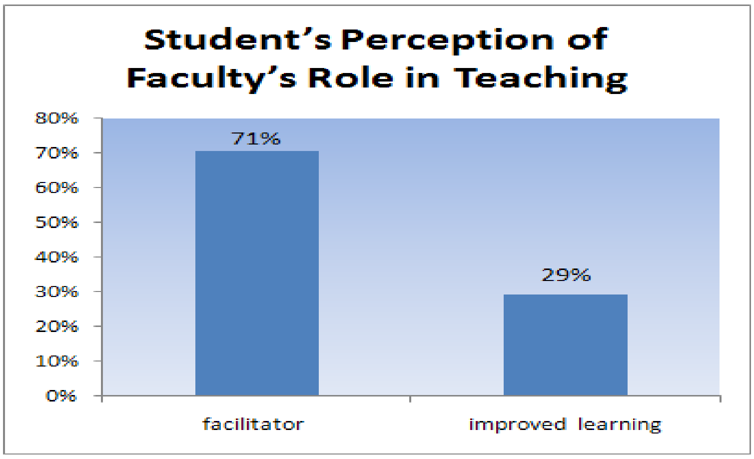

Figure 8: Impact of structured problem solving strategy on student's perception of faculty's role in teaching

100% of the students indicated the faculty's approach to teaching reflected a change. Figure 8 shows 71% described the faculty as a guide or facilitator and 29% commented the new role helped them learn better. The data suggests students perceived the shift in the faculty's role in the teaching process from a teacher to a facilitator.

The impact of structured problem solving on student's role in learning

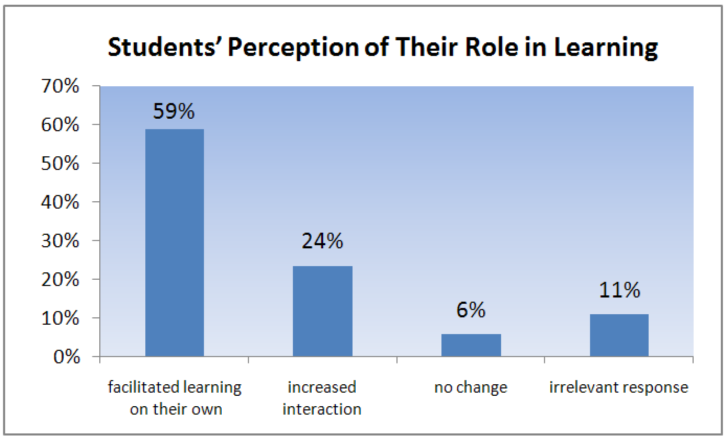

Figure 9: Impact of structured problem solving strategy on student's perception of their role in learning

Figure 9 shows 59% of the students reflected felt the new approach facilitated learning on their own. This was compared to 'copying a solution' or being 'spoon-fed' experienced in the more traditional approach. Other comments on this approach included 'facilitating pro-active learning', 'getting them to explore and decide what to learn', 'requiring them to help themselves', 'helping them to think and learn in an active way', ' facilitating finding answers on their own', ' promoting understanding rather than learning', 'facilitating looking for answers, 'not merely providing information by faculty but providing guidance in learning'. 24% indicated the approach increased their interaction during the lesson and 6% indicated no change to their role in learning.

The data suggests the role of the learner in the structured problem solving approach shifted from a passive receiver of information to an active engager in the learning process. The findings in Figures 1,2 and 3 suggests the structured problem solving approach promoted skills for autonomous learning and facilitated a shift in the role of faculty from 'teacher' to 'facilitator' creating a learning environment for students to take greater responsibility for their learning.

Students' preferences for structured problem solving approach

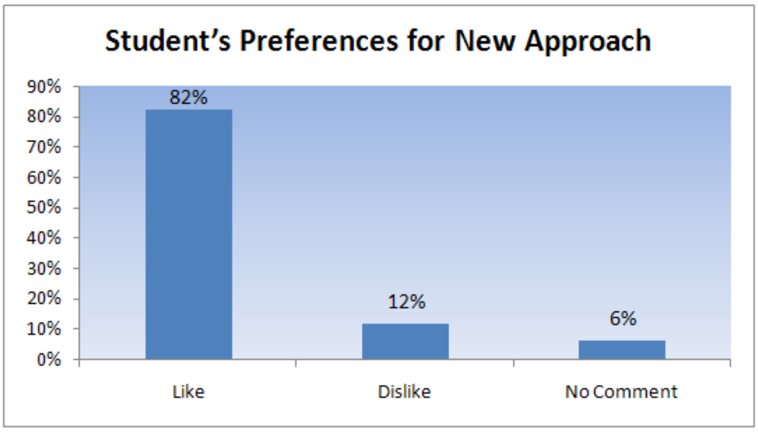

Figure 10: Students' preferences for structured problem solving approach

Figure 10 shows 82% of the students liked the new approach. 12 % did not like it and 6% commented it helped them establish a stronger bond with the faculty. The data from the comparison of approaches discussed later will help uncover further what students liked or disliked about structured problem solving.

Students' concerns about the structured problem solving approach and their suggestions for improvement

Some concerns were raised and improvements suggested in response to how the use of the method could be enhanced to maximise teaching include the need to (1) better manage time, (2) use computer labs, (3) provide the lesson plan ahead of time, (4) upgrade the computer system, and (5) use the visualiser where appropriate for hardcopy answers.

An important concern raised on the use of this approach was the 'content covered is reduced' and not all answers can be 'covered in great depth'. The concern for grades and the need for assurance that what needs to be learnt will be covered when using this strategy is an important one that needs consideration for this approach to work. Faculty could consider paying closer attention to providing feedback and support where necessary to facilitate the students towards greater autonomy (Brookfield, 1995).

Comparison of Traditional and Structured Problem Solving Strategies

Students' preference of strategies

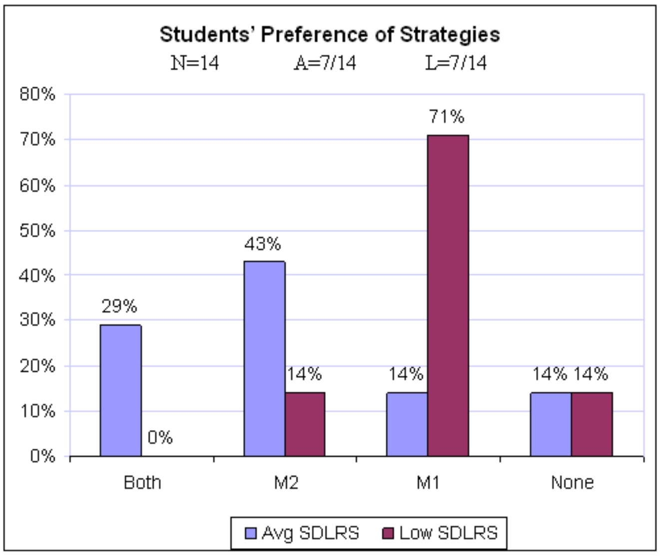

Figure 11: Students' preference of strategies

Figure 11 shows students who have average SDLRS scores prefer M2 (24%) as compared to M1 (14%). The next preferred option (29%) was a combination of both strategies. Among the reasons given for this preference was students could obtain more substantial notes in M2. On the other hand, students with low SDLRS scores preferred M1 (71%) as compared to M2 (14%). Among the reasons given was M1 was more interactive and it helped clarify doubts.

It seems students with low SDLRS scores prefer M1 (71%) as compared to M1 (14%) students with higher SDLRS scores. The higher scorers, who are already more self-directed, may not require structured support to help in facilitation of the autonomous skills. Perhaps a different strategy that would better match their level of SDLRS could be explored. Both Hiemstra (1994) and Grow(1991) suggest that the better match between the instructor's style of teaching and the student's SDLRS level, the better the facilitation of SDL in the leaning environment. In the same light, it is possible to add the better the match between the instructional strategy and the students SDLRS level, the better the facilitation of SDL in the learning environment.

Strategy that helped students learn better

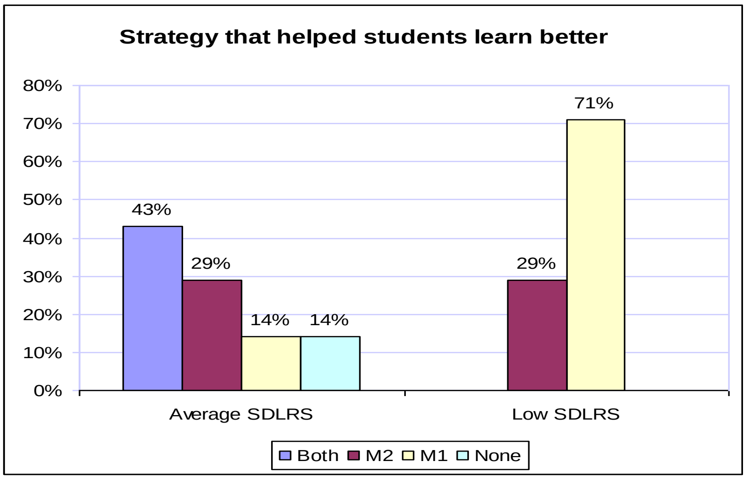

Figure 12: Strategy that helped students learn better

Figure 12 shows that Average SDLRS scorers learnt better using a combination (43%) of M1 and M2. Their next preferred method of learning was M2 (29%). The reasons given for the preference of M2 was it provided a clearer flow of information and the notes were available for reference at any time. Among the reasons given for choosing M1 was it was better because it provided a direct learning approach which enabled the learner to find out things on their own.

On the other hand, Low SDLRS scorers learnt better using M1 (71%). Among the reasons given was that it 'forced' the learner to focus on the lecture and it helped the learner remember better. Among the reasons given for M2 (29%) being a better method was it helped the learner learn as they could 'write notes'.

Of interest is that while Average SDLRS scorers preferred the M2 approach (43%), they indicate learning better using both methods (43%).The Low SDLRS scorers, on the other hand preferred M1(71%) and learnt better using the M1(71%) approach. The findings suggest that while both Average and Low SDLRS scorers learn better using M1 or a combination of M1 and M2, the Average SDLRS scorers prefer using M2 to learn. Preference for learning mode for Average SDLRS learners in this instance does not relate to the better learning method. On the other hand the preferred learning method for Low SDLRS scorers, M1 relates to the method that helps them learn better. Further investigation needs to be conducted to collect evidence of 'better learning' for both groups of learners and for both methods.

Likes and dislikes about the 2 methods

Table 1: Likes and dislikes for Method 1 & 2

Ave SDLRS Learners (M1)		Low SDLRS Learners (M1)	
Like	**Dislike**	**Like**	**Dislike**
4/7 interactive, help participate in learning, 2-way	3/7 cannot take notes, trouble and time-consuming	4/7more interactive 1/7help understanding 1/7 help me know what I don't know and where to find info	2/7 laptop troublesome, Google doc hassle 1/7 time consuming 1/7 less material covered
Ave SDLRS Learners (M2)		**Low SDLRS Learners (M2)**	
Like	**Dislike**	**Like**	**Dislike**
3/7 provides clear and necessary notes, more structured	2/7 Keep talking, cannot monitor understanding, non interactive	2/7 easier to find info, info easily available	1/7 not effective in helping understanding 1/7not interactive 1/7not very interesting 2/7 boring 1/7lose concentration

The data in Table 1 reflects the reasons given by students (n=7) for their likes and dislikes of the 2 teaching methods (M1&M2) used in the study. These responses help uncover the reason why Average SDLRS learners prefer as discussed in the previous paragraph, M2 over M1. It seems the main reason for their dislike of M1 (3/7) is it is troublesome to bring in laptops, it takes more time and they cannot take the notes they want as they are busy solving the structured problems. On the other hand, they like M2 mainly because (3/7) it provides clear and necessary notes and is more structured. It seems that while these students like the interactive style (4/7) in M1 and dislike the non-interactive style (2/7) in M2 where the lecturer keeps talking and learning cannot be monitored easily, the need for structured notes and convenience determines the preference of these groups of learners. It is possible as mentioned earlier that these students are already self-directed and so are already learning that way, and this approach which aims to promote autonomous learning is not fully appropriate for this purpose. A better match may need to be struck in the choice of instructional mode and student's SDLRS levels.

Low SDLRS scorers who prefer M1 over M2 indicated they like it (4/7) because it is more interactive, helps them understand, to know what they don't know and where to locate answers. They disliked M2 mainly because it was not interactive, not interesting, could not sustain their concentration and it was boring and ineffective in helping them gain the understanding they needed. It is interesting to note that although they too found (2/7) M1 troublesome, time consuming and with less content coverage as did the Average SDLRS scorers, and similar to them liked (2/7) M2 because it was more structured and easier to locate information , they did not opt for M2 as their preferred learning method.

The data seems to indicate the interactive nature of M1 as a strategy to promote learner autonomy using structured problems appeals to learners with Lower SDLRS scores because it is the option (71%) that helps them learn better as indicated in the previous segment. On the other hand, the Average SDLRS learners prefer M2 and opted for a combination of M1 and M2 (43%) as the strategy that helped them learn better.

Group scores (5 of 6 sets) for Pre- Post- Test (M1 & M2)

Table 2: Pre and post scores

Groups (Combined Av-Low)	M1 Pre-Post	M2 Pre-Post
WAV	40%	40%
JVJ	20%	60%
Leo	60%	100%
Netscape	0%	40%
Iron men	0%	20%
Mean	24%	52%

Table 2 suggests M2 helped students score better. The average difference shown in Table 2 for the performance outcomes is 52% for M2 and 24% for M1. While the tests were taken in groups comprising both the Average and Low SDLRS scores, it is worth mentioning that 'scoring better' and 'learning better' may not be synonymous in this context where the focus is on developing autonomous skills in the learning process. While the literature on autonomous processes states that improving these processes improves academic performance, students need to be given time to develop their skills sufficiently to be able to improve their learning outcomes or academic performance. As such, this aspect of measuring learning outcomes needs to be further explored. Also, as these scores were meant to promote autonomous learning in groups, obtaining individual scores will also help to give a better picture of how learning and scoring compare for both Ave and Low SDLRS learners.

Conclusion

The findings of this case study show structured problem solving can be used to promote the development of SDL skills for students to take greater responsibility for their learning. The students' responses also showed the approach promoted greater engagement in learning and 'forced' students to be active and know 'what was going on' while the faculty facilitated the learning process.

In spite of the many benefits cited by students for the use of M1, only Low SDLRS learners preferred this approach to the traditional approach. The Average SDLRS learners preferred the traditional approach because it saved time and was more structured though less interactive and less interesting. This was in spite of the fact that both groups indicated either M1 or a combination of the M1 and M2 as the better learning method. In addition to this, the group performance of learners comprising both Low and Average SDLRS scorers showed there was a larger improvement in learning outcomes using M2.

The areas uncovered for further study from this investigation include (1) how M1 can be modified to cater for Average SDLRS scorers who respond differently to this strategy from Low SDLRS scorers, (2) evidence of how M1 facilitates better learning as indicated by the students, and (3) how the stages of development in autonomous skills relate to learning outcomes as both may not develop synchronously.

Implications

This study has provided some useful insights to consider when transiting from a more TDL to a SDL approach to teaching and learning. Firstly, the study confirms the SDL literature that differences in readiness for SDL impacts on the learner's response to it. As such, when implementing a more SDL curriculum, information on student readiness should be used in the decisions about the types of strategies to introduce into a more SDL curriculum. Secondly, while improving learning by getting students to be more engaged in the process, there should also be a close monitoring of how students' learning outcomes are impacted. This is important to consider as the two outcomes may not be developing synchronously. Finally, while scaffolding and support are necessary for 'beginners' in SDL, the same may prove stifling for the more advanced SDL learners. An appreciation of these differences can make for learning environments that are inclusive and which cater for different learners.

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