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Evaluating the self-directed learning readiness of engineering undergraduates: a necessary precursor to project-based learning

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ABSTRACT: Contemporary learning environments have fewer structured learning activities and more self-directed learning tasks guided through consultation with academics. Such tasks are predominately project/problem-based where the student is required to follow a freely guided road map to self-discovery while simultaneously achieving the desired learning outcomes for a particular course. However, many students struggle to adjust to a learning environment where they are being increasingly encouraged to undertake Self-Directed Learning (SDL). Thus, in this article, the author proposes to evaluate the SDL readiness of final year engineering students. To achieve this objective, a questionnaire survey of 22 students (37% of the final year cohort) completing the civil engineering programme at Griffith University, Gold Coast, Australia, was conducted. Moreover, the relationship between a respondent's Grade Point Average (GPA) and their SDL readiness was determined. Through understanding students SDL readiness throughout their engineering programmes, academics can better tailor Project-Based Learning (PBL) support mechanisms to achieve the desired learning outcomes.

INTRODUCTION

Advances in technologies mean that students can now access a plethora of material through an Intranet or over the Internet to support their learning processes. However, the changing nature of the engineering industry requires constant changes to the educational process; further, our reliance upon technology should not be the only driving mechanism for educational advancement, eg ref. [1].

Modern engineering education programmes should prepare students for scenarios that mimic those faced by engineering practitioners. To some extent, Project-Based Learning (PBL) has helped students to cohesively conceptualise engineering fundamentals to develop holistically acceptable solutions for engineering problems [2][3].

However, students commencing an Australian engineering programme have often only been exposed to teacher-centred learning approaches. Teacher-centred learning has some advantages, but may not provide students with the necessary skills to tackle PBL activities. Students with some previous exposure to PBL should demonstrate higher rates of Self-Directed Learning (SDL) readiness.

The following sections provide a brief background on SDL with a particular emphasis on Giglielminos' readiness scale and PBL [4]. As this study focuses on the interrelationship between these two themes, it was deemed imperative to include a brief background on each. Following this, the research method for the study is provided. The study utilised questionnaire surveys to ascertain the students' self-directed learning readiness. The collected SDLRS ratings are then presented. Finally, the article finishes with a summary highlighting the importance of SDL aptitude development in engineering programmes.

SELF-DIRECTED LEARNING

SDL is a continuous engagement in acquiring, applying and creating knowledge and skills in the context of an individual learner's unique problems. SDL capabilities are critical in the ever-changing knowledge economy where the only constant is change. Instilling a life-long learning perspective implies that schools and universities need to prepare learners to engage in SDL processes. However, general consensus is that K-12 education is still largely teacher-centred. Moreover, many university programmes, including those in applied fields such as engineering, have only fractional components of activities that infuse SDL skills and these are usually in the final years of undergraduate programmes. When students are finally thrust into such tasks in their engineering programmes, they are largely unprepared and sometimes struggle to sufficiently adapt. Once they start to develop a basic skill set for SDL in their final year, they are catapulted into the engineering profession, where they will undoubtedly be expected to adopt an SDL approach from day one. Earlier SDL preparation will ensure a smoother transition to professional employment in engineering and other professional areas.

Two Likert-type instruments available for the assessment of readiness for SDL are Guglielminos' Self-Directed Learning Readiness Scale (SDLRS) and Oddi's Continuing Learning Inventory (OCLI) [4][5]. SDLRS is a better instrument since it addresses both attributes and skills along with its more extensive literature foundations. Moreover, greater evidence of its construct, content and criterion reliability and validity are also prevalent in the literature [6]. Thus, for the purpose of this article, the SDLRS was deemed as the most suitable instrument for soliciting an accurate measurement of readiness for SDL.

The version of the instrument used in the study was a self-scoring form. The self-scoring SDLRS is composed of three factors, namely:

- Self-management;
- Desire for learning;
- Self-control.

Each of these factors is composed of a number of items for rating SDLRS (see Table 1). Later sections provide a detailed description on the use of the SDLRS instrument in the context of this study.

PROJECT-BASED LEARNING

PBL has been defined as Problem and/or Project-Based Learning. The similarities are that both methods endeavour to mimic professional situations in either exploring a problem or a project with more than one way to either solve the problem or implement the project. For the purpose of this study, the term PBL was taken to mean Project-Based Learning, since all project-based activities involve *inter alia* problem-solving of one kind or another [7].

PBL aims to move students beyond traditional surface learning approaches concerned primarily with the gathering and memorising of facts and other forms of information to one that is characterised by learners understanding material, seeking meaning, relating concepts to experience, critically evaluating ideas and so on [8]. Birch argued that PBL was the most effective means of developing the general qualities of mind of the student, to securing an integration of academic and operational approaches to higher education and to instilling a high level of motivation and a capacity for active learning [9]. In an engineering context, PBL is undoubtedly an effective means for teaching and assessing a range of relevant skills and qualities needed by the graduate engineer. PBLE summarises the benefits of PBL as follows:

- Improved comprehension;
- Improved context and student motivation;
- Theory is learnt and applied in a situation resembling a work-based scenario;
- Improved communication skills for theory based content;
- Ability to apply theory to a real application;
- Improved retention [8].

Many universities offering engineering programmes across the globe are engaging with PBL as a preferred form of learning. Outstanding examples include Aalborg, Drexel, Windsor and Surrey. Closer to home, many Australian universities are presently involved in multi-million dollar initiatives implementing PBL into their engineering programmes. Engineers Australia (EA) views such steps to redesign curriculum around PBL as an opportunity to derive graduate competence requirements. Similar to the experiences in Australia, engineering institutions worldwide are beginning to demand more stringent requirements from accredited engineering programmes. Specifically, they want curriculum to be designed around graduate competences and that the development of those competences will dictate the type of delivery mode for course content; PBL being an obvious vehicle to achieve such competences at both the undergraduate and postgraduate levels [3].

Engineering at Griffith University, Australia, has recently merged from three different schools to one larger school, with a reconstructed undergraduate engineering programme that commenced delivery in 2007. This presents an excellent opportunity to explore the possibility of expanding PBL through Griffith's engineering curriculum, with the potential outcomes of improved student retention, increased motivation and improved graduate outcomes. This style of learning also has the added benefit that the University has a higher level of engagement with industry through course design that is more likely to ensure currency of curriculum. While some institutions have created entire engineering programmes based on PBL, the Griffith School of Engineering seeks to implement PBL as a major component of a broad portfolio of learning and teaching options. Others include research-based learning, work-integrated learning and traditional teacher-centred learning approaches.

RESEARCH METHOD

The literature analysis confirmed that SDLRS was the most appropriate instrument for determining SDL readiness. After the selection of the instrument, the cross-sectional study was designed and executed accordingly. This study solicited the perceptions of the final year cohort of students in the *Bachelor of Civil Engineering* programme. In total, 22 questionnaire surveys were completed by the final year class cohort, which represents a response rate of 37%.

The questionnaire survey contained two distinct sections. The first section solicited descriptive statistics on the participating respondents. This section enabled the establishment of a comprehensive respondent profile (ie age, industry, experience, Grade Point Average (GPA), etc). The second section requested respondents to provide their opinion about statements related to the SDLRS, ranging from *1 = strongly disagree* to *5 = strongly agree*. These SDLRS questions were categorised under three factors, namely:

- Self-management (13 items);
- Desire for learning (12 items);
- Self-control (15 items).

DATA ANALYSIS AND RESULTS

Respondent Profile

Only a fraction of the students were female (5%). As expected, for a fourth year engineering cohort, the majority of the students (73%) have progressed straight from secondary school and will finish their programme at the age of 21-23. The remaining students were relatively young with 22% aged between 24 and 26 and 5% aged 27 to 30. Most of the students (86.4%) had at least some engineering experience before commencing their final year of engineering. This high number is expected as Engineers Australia requires at least 12 weeks of industry experience to complete the engineering programme. Three of the students (13.6%) had at least one year of equivalent full-time industry experience. As expected, the students conducted work experience in a variety of areas under the civil engineering banner. Approximately one quarter of the students gained site-based engineering and project management work experience.

The undergraduate students were requested to estimate the breakdown of assessment items in their engineering programme. Reflecting the actual break down, the students stated that 50% of a course is typically examination-based and the remaining 50% fairly evenly spread between assignments, tutorial exercises, laboratories and projects. The small proportion of assessment devoted to Project-Based

Learning (PBL) is evident in the Griffith Engineering programme (9%).

Evaluating Self-Directed Learning Readiness

As previously mentioned, Giglielminos' (1977) SDLRS was utilised to evaluate each students SDL readiness. Table 1 details the range, mean and standard deviation for the 30 items comprising the three factors of the SDLRS, namely: self-management (SM), desire for learning (DL) and self-control (SC). The mean ratings for these items ranged from 2.86 (DL5) to 4.55 (DL11). Understandably, there are some large standard deviation scores indicating that the respondents had varied levels of SDL readiness.

The respondents appeared to have a high desire for learning (DL = 4.02) which was promising. Self-management was the lowest rating factor with a mean value of 3.45. This provides some hints that some students have difficulty managing their approach to learning.

For the self-management factor, two items relating to the planning and time management of study (ie SM4 and SM8) were the lowest. The busy lives of modern students that mix large working commitments with study may make it difficult to plan out a regular study routine. The respondents appeared to have a strong desire for learning indicated by the high mean values for a substantial number of the associated sub factors. DL5 had the lowest mean value in this factor (DL5 = 2.86) with a large standard deviation of 0.990 hinting that some students do not enjoy the current learning process. Moreover, the highly varied response for this item indicates that the students' motives for study are varied. Lastly, the majority of the respondents appeared to have the necessary self-control for study. For some reason, the lowest rated self-control item relates to setting one's own goals and evaluating own performance (SC15). This may not be surprising since not all people are naturally strategic in their approach to learning. It should be noted that the SDLRS was utilised in a later section to examine its relationship with a respondents' grade point average.

Relationship between GPA and SDLRS

In Part A of the questionnaire, the students were requested to provide their Grade Point Average (GPA). This question was included to determine whether or not those students who had performed well in their programme had simultaneously built SDL readiness attributes. The GPA at Griffith is on a scale from 0-7. Grades are provided as follows: Fail = 0; Pass Conceded = 3; Pass = 4; Credit = 5; Distinction = 6; and High Distinction = 7. The aggregation of grades from a student's transcript provides their GPA. Thus, for example, a GPA of 5.00 generally indicates a moderate performing student who has received (on average) a credit standard. The SDLRS of students for GPA-designated sub-samples was determined and illustrated in Figure 1. This figure shows a reliable ($R^2 = 0.71$) positive linear trend between GPA and SDLRS. Thus, it can be concluded that higher performing students in the engineering programme have also accumulated higher SDL readiness aptitude and visa versa. Employers of engineers want self-starters that can undertake complex problem solving tasks with minimum supervision. This study provides some evidence that they should appoint students with higher GPAs since these students should be in a better position to tackle whatever challenge is thrown at them in their future employment.

Table 1: SDLRS items range, mean and standard deviation.

Item Code	*Factor* Sub-Factor (Item)	Mean	Std. Dev.
SM	*Self-management*	*3.45*	*0.845*
SM1	I manage my time well	3.32	0.995
SM2	I am self-disciplined	3.55	0.739
SM3	I am organised	3.55	0.800
SM4	I set strict timeframes	3.09	1.109
SM5	I have good management skills	3.64	0.790
SM6	I am methodical	3.77	0.752
SM7	I am systematic in my learning	3.55	0.739
SM8	I set specific times for my study	2.91	1.192
SM9	I solve problems using a plan	3.50	0.859
SM10	I prioritise my work	4.18	0.853
SM11	I can be trusted to pursue my own learning	4.09	0.811
SM12	I prefer to plan my own learning	3.50	0.740
SM13	I am confident in my ability to search out information	3.91	0.610
DL	*Desire for learning*	*4.02*	*0.662*
DL1	I want to learn new information	4.32	0.477
DL2	I enjoy learning new information	4.36	0.581
DL3	I have a need to learn	3.82	0.733
DL4	I enjoy a challenge	4.14	0.468
DL5	I enjoy studying	2.86	0.990
DL6	I critically evaluate new ideas	3.64	0.790
DL7	I like to gather facts before I make a decision	4.23	0.612
DL8	I like to evaluate what I do	3.45	0.800
DL9	I am open to new ideas	4.27	0.550
DL10	I learn from my mistakes	4.36	0.658
DL11	I need to know why	4.55	0.596
DL12	When presented with a problem I cannot resolve I will ask for assistance	4.23	0.685
SC	*Self-control*	*4.05*	*0.645*
SC1	I prefer to set my own goals	3.95	0.785
SC2	I like to make decisions for myself	4.23	0.528
SC3	I am responsible for my own decisions/actions	4.36	0.492
SC4	I am in control of my life	4.36	0.658
SC5	I have high personal standards	4.36	0.581
SC6	I prefer to set my own learning goals	3.86	0.640
SC7	I evaluate my own performance	3.73	0.767
SC8	I am logical	4.10	0.625
SC9	I am responsible	4.27	0.631
SC10	I have high personal expectations	4.23	0.612
SC11	I am able to focus on a problem	4.00	0.756
SC12	I am aware of my limitations	3.82	0.795
SC13	I can find out information for myself	3.90	0.539
SC14	I have high beliefs in my abilities	4.00	0.690
SC15	I prefer to set my own criteria on which to evaluate my performance	3.64	0.581

Figure 2 presents the relationship between GPA and individual SLDRS factors (ie SM, SC and DL). It was pleasing to see that most of the students, regardless of their GPA, had a strong desire for learning. However, it appears that poor self-management is a student's downfall and may often result in a lower academic performance. To a lesser extent, self-control is also a strong predictor of academic performance. These charts provide evidence to education practitioners seeking to improve academic performance. Benchmarking of SDL readiness early and informing students at risk could assist them to work on changing their habits and approaches to learning. All such efforts will lead to the more rapid development of SDL abilities.

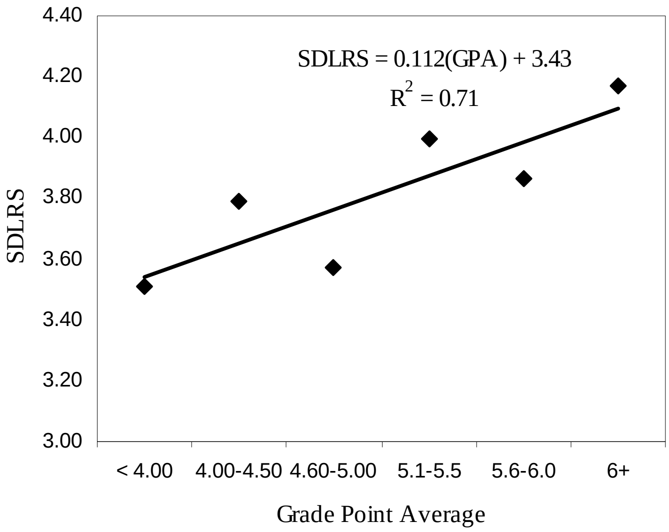

Figure 1: Relationship between GPA and SDLRS.

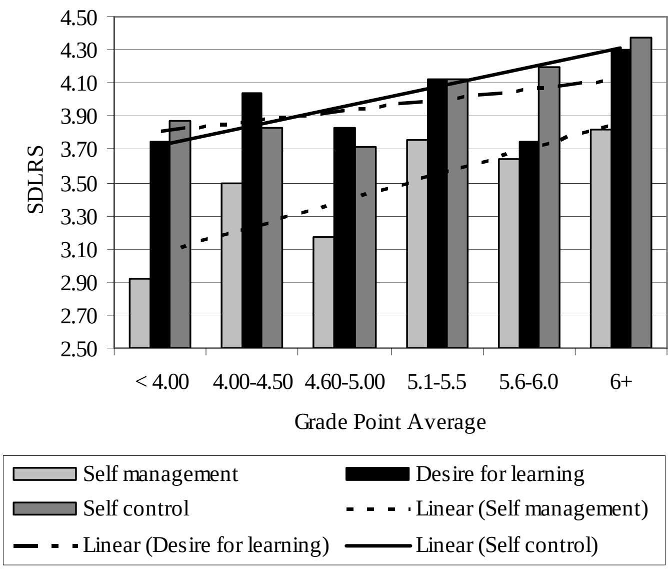

Figure 2: Relationship between GPA and SDLRS factors.

SUMMARY

Griffith Engineering School, along with many other higher education providers globally, are slowly incorporating PBL into their undergraduate and postgraduate programmes. However, the transition to PBL is not an easy one due to a number of internal and external environment barriers. Firstly, internally within existing engineering schools, the academic staff may be reluctant to embrace PBL and those who are accepting may not have the imagination and knowledge to make it work. Also, entire engineering programmes, as well as the courses contained within, need to be totally restructured to ensure that PBL is not applied *ad hoc* but seamlessly embedded. Such an undertaking requires motivated staff and a serious investment in strategic resources. Secondly, the external barriers, including, secondary education systems still predominately adopting teacher-centred learning approaches, higher working commitments of students, to name a few, all make PBL difficult to effectively implement. These internal and external barriers have contributed to the creation of students with a limited SDL readiness.

SDL aptitude is one key outcome from PBL and appropriate SDL readiness is also a precursor for extracting higher levels of learning from PBL environments. Graduating students with heightened SDL aptitude is one of the best outcomes an engineering education provider can offer the professional employment market. Thus, as hinted in this article, the measurement of SDL readiness at various stages of a student's enrolment in an engineering programme may be an essential process to ensure that the learning outcomes are achieved, especially where PBL is employed. More importantly, such measurements may help convenors to construct programmes that gradually develop SDL skill levels to suit assigned PBL tasks (ie as SDL readiness develops, so does the difficultly of PBL tasks). Additionally, such measurements could even be used to identify and assist students at risk in PBL environments. Regardless of a student's educational background, the structured and continual evaluation of SDL readiness will undoubtedly lead to engineering graduates who are highly employable in a range of industry sectors.

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