

Relationship between self directed learning readiness factors and learning outcomes in third year project-based engineering design course

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***Abstract:** Contemporary learning approaches have fewer structured learning activities and more self directed learning tasks guided through consultation with academics and tutors. Such tasks predominately follow a project and/or problem based learning (PBL) mantra where an individual student or a team of students is required to follow a freely guided road map to complete the tasks whilst simultaneously achieving desired learning outcomes for a particular course. However, many students struggle to adjust to such a learning environment where they are being increasingly encouraged to undertake self directed learning (SDL) activities. This paper utilises questionnaire survey approach to evaluate the SDL readiness factors and course learning outcomes for a large class of third year undergraduate civil engineering students at Griffith University, Australia. The results of the study showed that students with a higher grade point average (GPA) also typically had a higher SDL readiness; however learning outcomes achieved by the students from this PBL course were higher for those with a moderate GPA (i.e. 5 or credit average). This suggests that students performing moderately in their former fundamental engineering courses, had higher learning outcomes from this PBL course and higher achievers did not perceive to learn as much. A final overarching finding was that this course provided the necessary skills for students to confidently tackle PBL based courses in the future; undoubtedly the precursor for engineering graduate functions.*

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, and our reliance upon technology should not be the only driving mechanism for educational advancement (e.g. Coates 2000; Toft *et al.*, 2003). Modern engineering education programs should prepare students for scenarios which mimic those faced by engineering practitioners. Project-based learning (PBL) has helped, to some extent, students to cohesively conceptualise engineering fundamentals to develop holistically acceptable solutions for engineering problems (e.g. Woods *et al.*, 2000; Gibson, 2003; Mills and Treagust, 2003; Ribeiro and Mizukami, 2005). However, most engineering courses in Australian universities are still taught using traditional teacher centred approach. Teacher centred learning approach has some advantages but may not provide students with the necessary skills to tackle PBL activities.

PBL endeavours to mimic professional situations in either exploring a project or a problem with more than one way to either solve the problem or implement the project. 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 (PBLE, 2003).

Birch (1986) 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. 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 (2003) summarises the benefits of PBL as: 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; and improved retention.

Many universities offering engineering programs across the globe are engaging with PBL as a preferred form of learning. In Australia, Engineers Australia (EA), accreditation body for Australian engineering programs, views such steps to re-design curriculum around PBL as an opportunity to derive graduate competency requirements. Specifically, they want curriculum to be designed around graduate competencies and that the development of those competencies will dictate the type of delivery mode for course content; PBL being an obvious vehicle to achieve such competencies at both the undergraduate and postgraduate levels (Ribeiro and Mizukami, 2005). However, the preliminary research results on success of PBL approach are not clear-cut and the students' attribute, particularly the self-directed learning (SDL) readiness has been flagged as necessary pre-requisite to PBL success (Stewart, 2007).

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 lifelong 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 programs, including those in applied fields such as engineering, have only fractional components of activities which infuse SDL skills. When students are finally thrust into PBL activities in their engineering programs 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 a 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' (1977) self-directed learning readiness scale (SDLRS) and Oddi's (1986) continuing learning inventory (OCLI). 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 (e.g. Delahaye and Smith, 1995; Maltby *et al.*, 2000). Thus, for the purpose of this paper 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 and self control. Each of these factors is composed of a number of items for rating SDLRS.

Since the last few years, Griffith University has been exploring 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 the industry through course design which is more likely to ensure currency of curriculum. Whilst some institutions have created entire engineering programs based on PBL, the Griffith School of Engineering has been gradually implementing 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

As previously mentioned, the primary objective of this study was to establish the links between undergraduate students' skills and abilities, SDLRS and learning outcomes (LO) of a large class of third year undergraduate civil engineering students. Literature synthesis confirmed that the SDLRS

was the most appropriate instrument for determining SDL readiness. After selection of the instrument, the cross-sectional study was designed and executed accordingly. This study solicited the perceptions of a cohort of 120 students who completed Civil Engineering Design Project in 2009. This course is core in the Bachelor of Civil Engineering program. In total, 60 questionnaire surveys were completed by the class cohort representing a response rate of 50%. The questionnaire survey contained five distinct sections. The first section solicited descriptive statistics on the participating respondents. This section enabled the establishment of a comprehensive respondent profile (i.e. gender, age, industry experience, previous years' academic achievements, i.e., 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) and self control (15 items). The third section asked respondents to rate their experience with the major PBL design project and associated tasks conducted in this course. The purpose of this section was to ascertain the students' difficulties and confidence with undertaking an unfamiliar project before and after completing this course and whether they believed that the course improved their job readiness. Finally, the last section asked respondents to rate a number of questions relating to the extent to which they perceived that they achieved particular learning outcomes from the course, on a scale ranging from '1 = not at all' to '5 = great extent'. Apart from descriptive analysis techniques, regression analysis was utilised to determine the relationship between construct and overall ratings for SDLRS and those for LO, for GPA groupings (i.e. <4, 4-4.5, etc.).

Data analysis and results

Respondent profile

Only a fraction of the respondents were female (6.8%). The majority of students were in their early twenties (more than 50%) with only a small fraction being over thirty years of age (10%). The majority of the students (43.3%) had progressed straight from secondary school and another 25% had less than 6 months of work experience. Only 5% of the students had more than 5 years of work experience. The majority of students' grade point average (GPA) before commencing this course was between 5.0 and 6.0 (35.5%) with 27.1% being more than 6.00.

Evaluating self directed learning readiness

Giglielminos' (1977) SDLRS was utilised to evaluate each students SDL readiness. Table 1 details mean and standard deviation for the thirty items comprising the three factors of the SDLRS, namely, self management (SM), desire for learning (DL) and self control (SC). Mean ratings for these items ranged from 3.12 (SM4) to 4.45 (DL1). 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 with a mean value of 4.10 which was promising. Self management was the lowest rating factor with a mean value of 3.70. 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 (i.e. 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 (3.32) with a large standard deviation of 1.08 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 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' GPA and PBL learning outcomes.

Table 1: SDLRS items mean and standard deviation

Item code	Factor Sub factor (item)	Mean	Std. Dev.
SM	<i>Self Management</i>	3.70	0.88
SM1	I manage my time well	3.43	0.96
SM2	I am self disciplined	3.87	0.72
SM3	I am organised	3.57	0.91
SM4	I set strict time frames	3.12	0.93
SM5	I have good management skills	3.65	0.90
SM6	I am methodical	3.90	0.86
SM7	I am systematic in my learning	3.90	0.75
SM8	I set specific times for my study	3.39	1.10
SM9	I solve problems using a plan	3.57	0.89
SM10	I prioritise my work	4.07	0.80
SM11	I can be trusted to pursue my own learning	4.02	0.81
SM12	I prefer to plan my own learning	3.52	1.00
SM13	I am confident in my ability to search out information	4.05	0.79
DL	<i>Desire for learning</i>	4.10	0.80
DL1	I want to learn new information	4.45	0.70
DL2	I enjoy learning new information	4.43	0.65
DL3	I have a need to learn	4.07	0.80
DL4	I enjoy a challenge	4.13	0.79
DL5	I enjoy studying	3.32	1.08
DL6	I critically evaluate new ideas	3.77	0.87
DL7	I like to gather facts before I make a decision	4.17	0.64
DL8	I like to evaluate what I do	3.92	0.74
DL9	I am open to new ideas	4.22	0.74
DL10	I learn from my mistakes	4.35	0.84
DL11	I need to know why	4.23	0.91
DL12	When presented with a problem I cannot resolve I will ask for assistance	4.17	0.85
SC	<i>Self control</i>	4.08	0.74
SC1	I prefer to set my own goals	3.93	0.80
SC2	I like to make decisions for myself	4.12	0.61
SC3	I am responsible for my own decisions/actions	4.37	0.66
SC4	I am in control of my life	4.17	0.72
SC5	I have high personal standards	4.32	0.65
SC6	I prefer to set my own learning goals	3.85	0.80
SC7	I evaluate my own performance	3.82	0.85
SC8	I am logical	4.05	0.75
SC9	I am responsible	4.27	0.66
SC10	I have high personal expectations	4.25	0.78
SC11	I am able to focus on a problem	4.13	0.75
SC12	I am aware of my limitations	3.98	0.81
SC13	I can find out information for my self	4.02	0.77
SC14	I have high beliefs in my abilities	4.12	0.67
SC15	I prefer to set my own criteria on which to evaluate my performance	3.78	0.80

Evaluating the effects of PBL learning experience

The respondents were requested to answer a number of questions related to their experience with their recently completed PBL course and associated tasks as a whole. In order to ascertain whether the students had gained some abilities from the PBL course and tasks, they were asked how difficult they found the project to get started and also, if they were required to plan another similar project again in their future, how difficult they would find it (Figure 1).

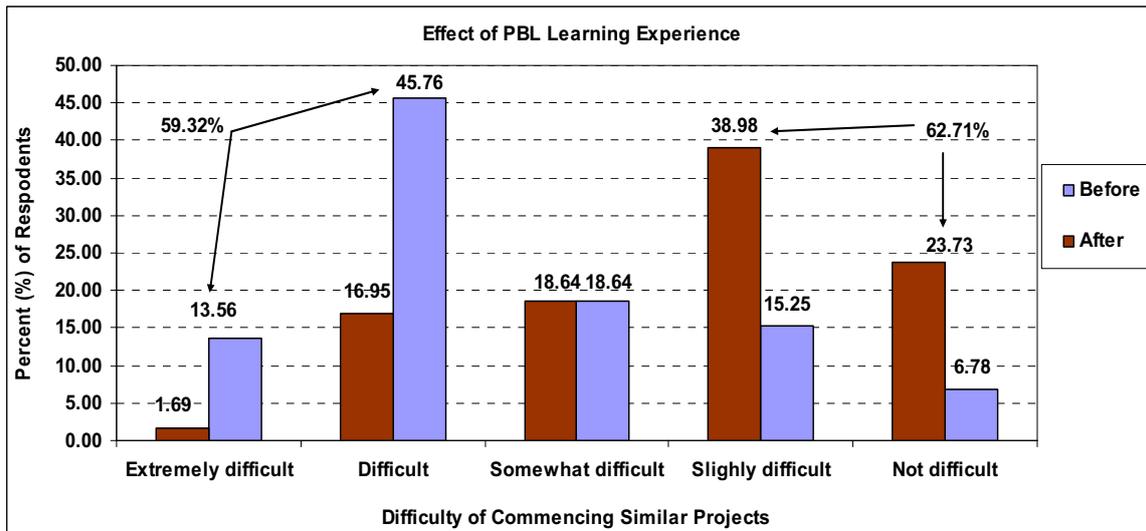


Figure 1: Perceived difficulty commencing similar projects: before and after

Less than 20% of students stated that if they had to plan a project again, they would find it difficult/extremely difficult (down from 59.32%) and 62.71% would find it not difficult/slightly difficult (up from 22.03%). This is an encouraging result given a large class of students with varied skills and abilities. Similarly, they were asked how confident they would be to tackle a large project exercise pre- and post- course completion (Figure 2). Less than 30% of students stated that if they had to plan a project again, they would not be confident or would be slightly confident (down from 64.4%) and 31.61% would be confident/extremely confident (up from 13.55%). Moreover, 40% of the students would have some level of confidence in tackling another project (up from 22.03%). Heightened confidence could be instilled by incorporating more PBL courses within engineering programs. Together, both of these questions provide solid evidence that the adopted PBL approach has enhanced their capability to handle large ‘real world’ civil engineering design projects.

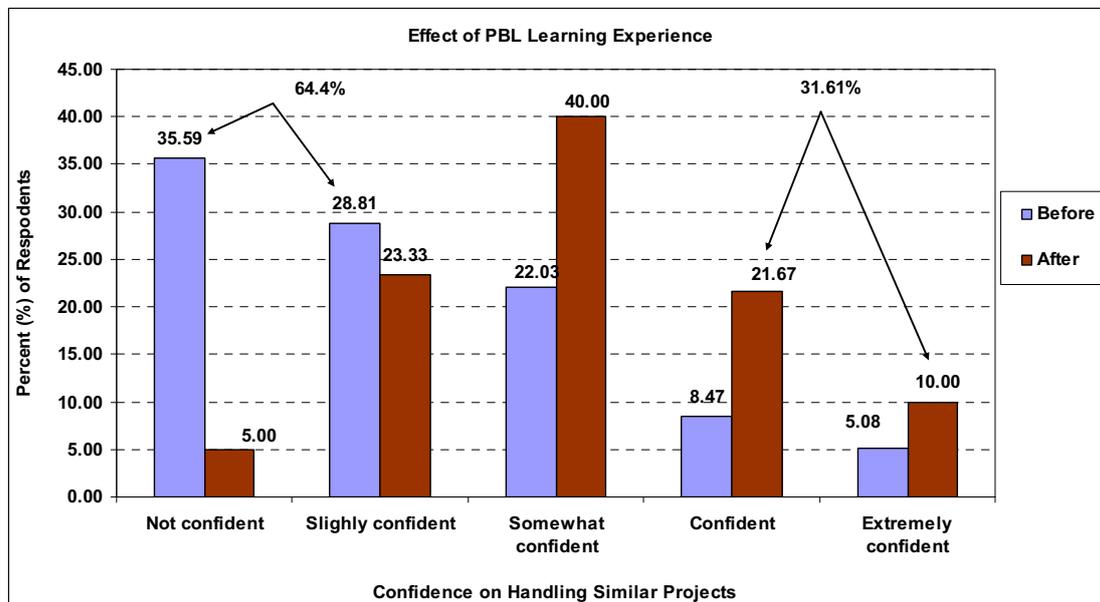


Figure 2: Perceived confidence in handling similar projects: before and after

As the majority of the assessment items in this course were team-based, students were asked how they worked in a team. 15.3% of the students stated that they had poor/very poor teamwork relationships indicating that some students did not work well with their teammates. However, the majority of them (56.6%) had good/very good relationships and the remaining 27.1% had an average relationship with their teammates. Further, the students were asked whether they preferred an examination based on the

course content, rather than a 100% PBL design project with a number of assessable components. The majority of the students preferred the PBL approach (72.9%) and remaining (27.1%) preferred traditional assessment items (Figure 3). This is unusual since students almost always prefer assignment based assessment. Unfamiliarity with such a large scale open-ended PBL project where the requirements, processes and outcomes are not fixed may be feared by some engineering students who prefer structured approaches to achieving solutions. Whilst 27.1% of respondents preferred a traditional assessment approach, 84.5% have admitted that this approach has helped their job readiness. An in-depth review of respondents preferring traditional course assessment items, revealed that there was a disproportionately high frequency of 6+ GPA students, suggesting that given their success with this type of learning, they potentially felt that team orientated PBL tasks involved unknown risks that could jeopardise their academic performance.

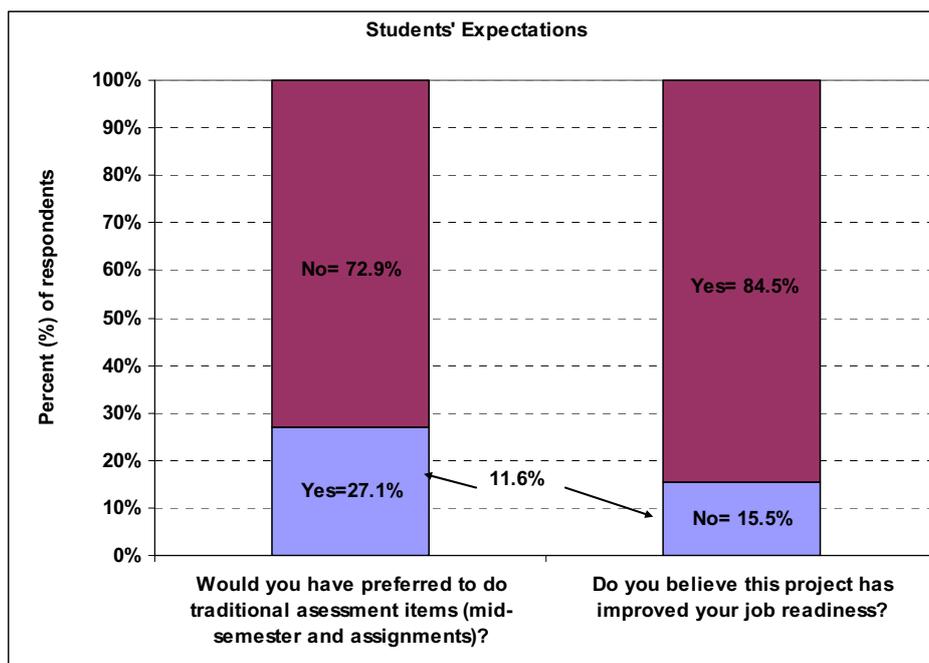


Figure 3: Conflict between students' expectations of job readiness & study tasks

Establishing the relationships between SDLRS, LO and GPA

In the questionnaire, the students were requested to provide their GPA, within specified ranges, when they started this course. This question was included to determine whether or not those students that had performed well in their program had also developed SDL readiness attributes and also received the most out of the PBL course (high LO scores). The SDLRS and LO of students for clustered samples, based on their GPA range (e.g. 4-4.5), was determined and illustrated in Figure 4. This figure shows a reliable ($R^2 = 0.65$) positive linear trend between GPA and SDLRS. Thus, we can conclude that higher performing students in the engineering program 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 GPA's since these students should be in a better position to tackle whatever challenge is thrown at them in their future employment. However, it is interesting to note that average or slightly above average students achieved more from PBL courses than both very low performing students and very high performing students. The reasons for very high performing students not achieving the same level of LO as moderate performers may be due to a range of reasons, including, the uncertainty created when working in a team on an open-ended design project to derive an outcome that is not defined in the same manner as traditional courses. The primary objective of this paper was to determine whether SDL readiness was a key predictor on the extent to which the cohort of students gained LO from the assigned PBL course and associated activities. To achieve this objective, the mean values of SDLRS were plotted against the overall mean LO values, stratified by

their GPA ranges (Figure 5). A polynomial ($R^2=0.69$) fitted well with the data indicating that those students that rated slightly above average score on the SDLRS gained more from a PBL structured course. This figure reinforces the prior discussion that high GPA students also having the highest aptitude for SDL did not extracted higher LO levels from the PBL experience.

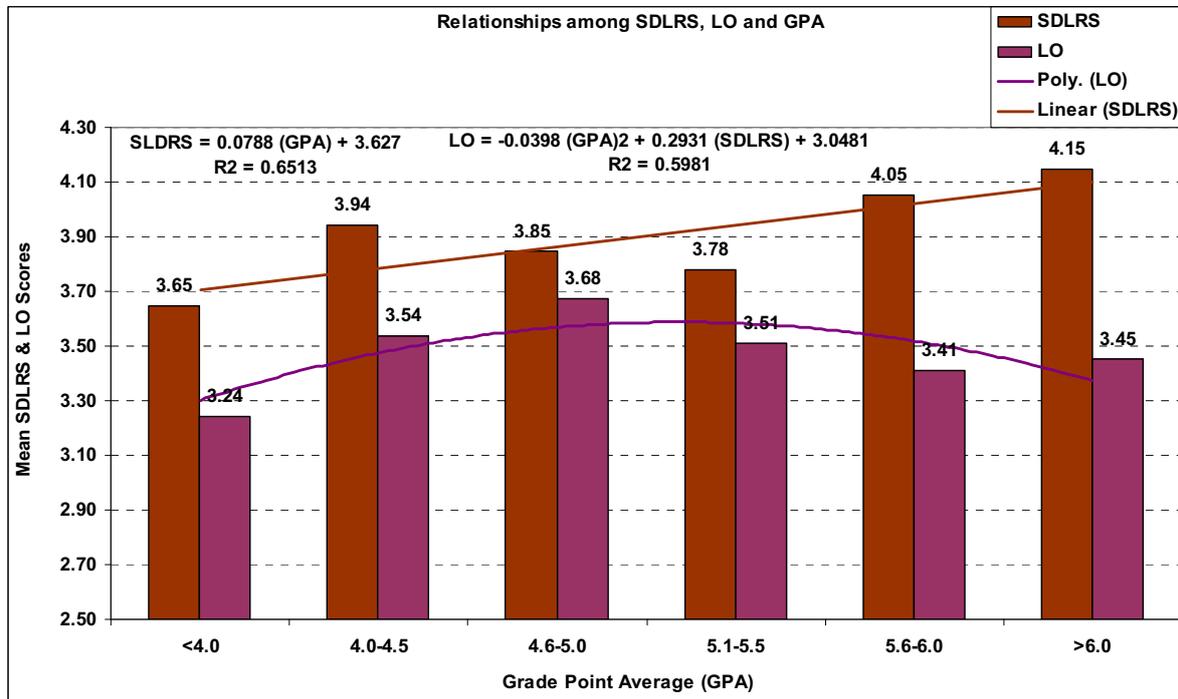


Figure 4: Relationship between GPA with SDLRS and LO

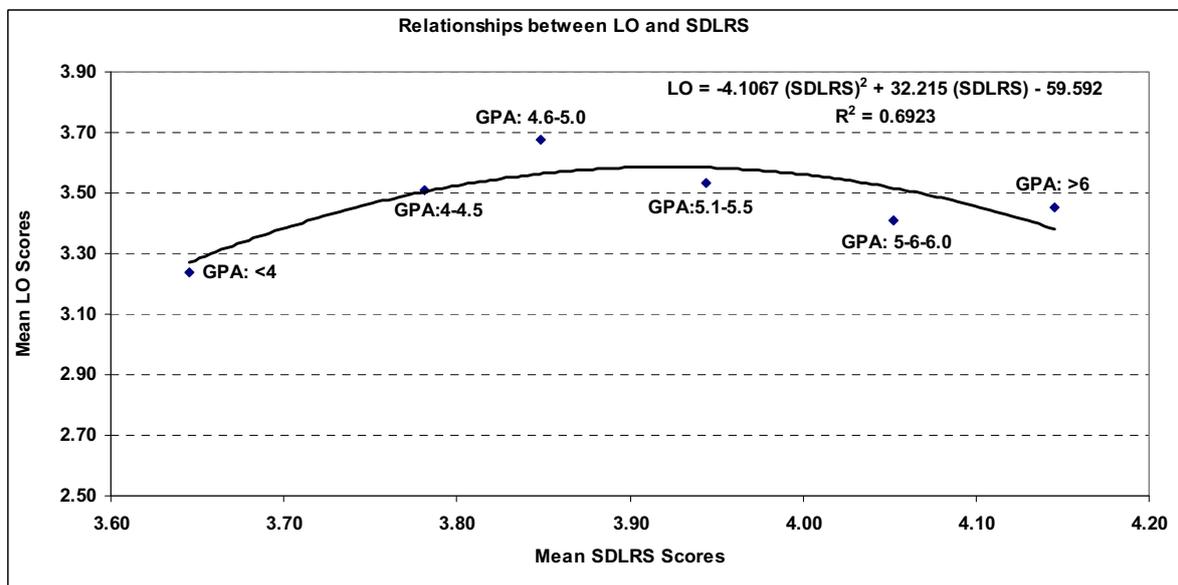


Figure 5: Relationship between SDLRS and LO for GPA clusters

Summary

Self-directed learning (SDL) aptitude is one key outcome from project-based learning (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 to the professional employment market. This study revealed an interesting finding that the very high performing students in terms of SDL and grade point average (GPA) did not achieve the same level of learning outcomes (LO), as moderate performers, in this PBL

based project. This is somewhat different result than what engineering educators usually say about the best students. Whilst the determinants of this relationship were not determined, engineering program convenors need to be aware that PBL based courses need to be integrated in the early stages of an engineering program in order to cultivate appropriate skills and must cater to a range of student performances, to ensure engagement from all students. Regardless of a student's educational background, the structured and continual evaluation of SDL readiness will undoubtedly lead to engineering graduates which are highly employable in a range of industry sectors.

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