

Assessing Readiness for Lifelong Learning

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Abstract

In general, lifelong learning can occur in two modes: formal and informal. Formal (or directed) modes include university courses or corporate training, whereas the informal modes, which occur naturally as part of learning to accomplish work tasks, are “self-directed.” The work presented in this paper focuses on assessment related to students’ ability to engage in self-directed learning and some early attempts at course enhancement to allow students to develop their abilities to engage in self-directed learning. The Self-directed Learning Readiness Scale (SDLRS) is used to assess of readiness for self-directed learning. In a preliminary study, this instrument was administered to approximately 60 senior engineering students to investigate the extent to which it correlated with academic performance as indicated by grade-point average. In a second study, the SDLRS is being taken by randomly selected first-year, sophomore, junior, and senior engineering students to determine how the readiness for engaging in self-directed learning changes during their engineering studies. Finally, two new, problem-based learning courses were implemented to enhance students’ learning as well as their readiness for self-directed learning. The students were given the SLDRS as a pre-test and post-test to determine whether the new courses enhanced their readiness for self-directed learning. These two new courses are briefly described and the results of the assessment are presented.

Introduction

The ABET Engineering Criteria 2000 (EC2000) bring lifelong learning to the forefront for engineering educators. In the past, our role in lifelong learning was primarily offering courses and degree programs for practicing engineers through continuing education and on our campuses. Now EC2000 demands that we prepare engineering students to engage in lifelong learning. While this demand on faculty and curricula to prepare students for lifelong learning is new, the significance attached to lifelong learning, and in particular continuing education, within the engineering profession is not.

Lifelong learning in engineering has been recognized as critical for decades. The Final Report of the Goals Committee on Engineering Education, written in 1968, contained a discussion of the importance of lifelong learning.¹ In 1978 the theme of the ASEE Annual Conference was “Career Management – Lifelong Learning.” Over the years there have been a number of studies to investigate the types of activities involved in lifelong learning, their frequency of use, the types of support systems required for lifelong learning, barriers to lifelong learning, and impact

of lifelong learning for individual engineers. Many of these studies are summarized in a 1985 report by an NRC panel.²

Lifelong learning is an issue of importance for engineers around the world. UNESCO sponsored several significant studies including “Advances in the continuing education of engineers.”³ The report resulting from this study summarizes practices in continuing education in a number of countries, both developed and developing, and also the delivery systems used. UNESCO played a central role in the formation of the International Society for Continuing Engineering Education in 1986.

Clearly, however, lifelong learning occurs through more channels than just continuing education. In 1986, Cervero *et al.* interviewed nearly 500 engineers in the area of Rockport, IL by telephone.⁴ Seventy-two percent of the engineers surveyed were at the BS level and more than one half were under the age of 35. Due to the nature of the businesses in the area, the sample contained predominantly mechanical engineers, 53%, with electrical engineers accounting for an additional 22%. The survey was structured to investigate the participation of the engineers in the three modes of learning proposed by Houle⁵: instruction, inquiry, and performance. Cervero *et al.* summarize these three modes of learning as follows:

“Instruction is the process of disseminating established skills or knowledge in traditional formats such as formal courses or seminars. Inquiry is the process of creating a new synthesis of ideas, techniques, policies or strategies. ... The mode of performance is the process of internalizing an idea or using a practice habitually so that it becomes basic to the way a professional practices.” (p. 112)

The authors go on to note that learning is usually a by-product of inquiry, rather than an expected outcome of the process. In terms of frequency of participation, the authors divide their findings into formal (instruction) and informal (inquiry and performance) and note that informal modes are more frequently used, “perhaps because most of these activities are embedded in the daily routines of work.”

The formal modes of learning occur in traditional university courses or corporate training and tend to be highly “directed” with the instructor guiding the learning very closely. On the other hand, the informal modes, which occur naturally as part of learning to accomplish work tasks, are much more “self-directed,” in that the learner must decide what is to be learned, choose an approach to learning, and manage the learning process independently. This distinction between formal/directed learning and informal/self-directed learning has guided the on-going work at Penn State, with the emphasis of the study being on informal/self-directed learning. The work presented in this paper focuses on assessment related to students’ ability to engage in self-directed learning and two pilot projects to enhance courses in ways that allow students to develop their abilities to engage in self-directed learning.

Selection of Instrument

In his paper, “Undergraduate Foundations for Lifelong Learning,” Flammer⁶ proposes a model for successful lifelong learning that has two aspects: motivation and ability. He divided each parameter into two areas. For motivation, these are “won’t do” and “will do,” and for ability,

they are “can do” and “can’t do.” The successful life long learner was then one who “will do” and “can do.” This model emphasizes the two critical factors in lifelong learning: motivation and skills. His discussion and insights are quite consistent with the current literature on self-directed learning that identifies these same factors. For example, Garrison includes these very same factors, albeit at a more detailed level, in her model for self-directed learning.⁷

Candy, in his extensive review of self-directed learning, summarizes the characteristics of the self-directed learner from many sources.⁸ These characteristics fall into two sets, personal attributes and skills, that area analogous to Flammer’s “will do” and can do.” Candy’s lists are:

“Will do” Attributes: curious/motivated, methodical/disciplined, logical/analytical, reflective/self-aware, flexible, interdependent/interpersonally competent, persistent/responsible, venturesome/creative, confident, independent/self-sufficient.

“Can do” Skills: have highly developed information seeking and retrieval skills, have knowledge about and skill at the learning process, develop and use criteria for evaluating (critical thinking).

A major issue in lifelong learning is how to assess the extent to which students are prepared to engage in it and also their willingness to do so, i.e., Flammer’s “can do” and “will do” characteristics of the lifelong learner. Two instruments for assessing lifelong learning are Gugliemino’s Self-directed Learning Readiness Scale (SDLRS), developed in 1978,⁹ and Oddi’s Continuing Learning Inventory (OCLI), developed in 1984.¹⁰ Candy notes that the SDLRS is widely used, especially in the area of adult education.⁸ During the development of the SDLRS eight factors were identified that contribute significantly to the ability to engage successfully in lifelong learning. These factors were labeled as: openness to learning opportunities, self-concept as an effective learner, initiative and independence in learning, informed acceptance of responsibility for one’s own learning, a love to learn, creativity, future orientation, and the ability to use basic study skills and problem-solving skills. Thus, the scale includes factors related to skills and personal attributes required for self-directed learning. In addition to its use as a measure of readiness for lifelong learning, this instrument has also been used as a learning styles measure to determine the extent to which students prefer self-directed learning.

Candy notes that in spite of its widespread use, the SDLRS has not escaped criticism in the literature.⁸ Other researchers have questioned the original analysis that was used to identify the eight factors within the instrument; consequently, the creator of the SDLRS is now recommending that only the total score be used as an indicator of readiness to engage in self-directed learning. Based upon the assertion that the ability to engage in self-directed learning is highly contextual, Candy raises the issue that both the SDLRS and the OCLI treat self-directed learning as context-free. He questions whether either instrument is a good measure of self-directed learning ability. Even though the SDLRS has been criticized in the literature, it is the most widely used measure of its kind; therefore, it was selected for use in the present work based upon the large base of work that is available to assist in its interpretation.

Results for Senior Engineering Students

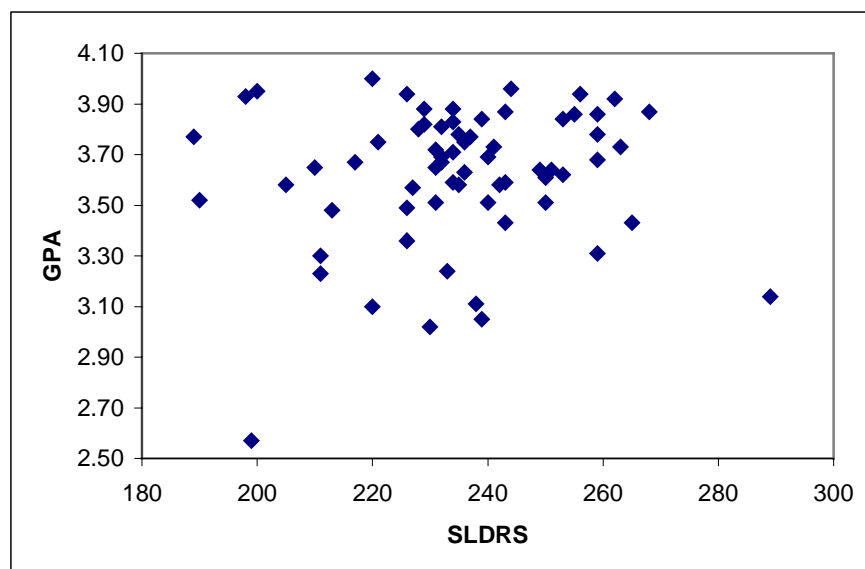
A self-scoring version of the SDLRS was obtained and administered to two groups of senior engineering students who serve as Teaching Interns in the College of Engineering.¹¹ Each of the departments in the College selects students to participate as Teaching Interns based upon academic records and expected ability to be effective in helping other students learn through office hours and help sessions. Thus, the students selected as Teaching Interns are among the most successful in terms of course grades. The SDLRS was administered to 36 teaching interns in 1999 and 35 in 2000. The mean and standard deviations of the results for the two groups as well as their average grade point average (GPA) are presented in Table 1. The average score of the students fell in the range considered to be “above average” by the designers of the instrument, which is 227-251. Nearly 25% (18 students) fell below the lower end of the “above average” range, while 15 students scored in “high” range.

Table 1. SDLRS Results and Student Characteristics for Teaching Interns

	1999	2000
Average SDLRS score	234	237
Std. Deviation in SLDRS score	20	19
Average GPA	3.64	3.60
Std. Deviation in GPA	0.23	0.31

Figure 1 presents a plot of the SDLRS scores versus GPA for all students in the sample for which GPA could be obtained. It clearly shows that there is little correlation between the SDLRS score and the GPA. Regression of the GPA against SLDRS score resulted in an $R^2 = 0.012$. This lack of correlation is not difficult to rationalize because traditional approaches to teaching do not ask the students to undertake much self-directed learning. Thus grades earned in such classes should not be expected to correlate strongly with the score on the SDLRS.

Figure 1. GPA versus SDLRS score for senior engineering students



Cross-sectional Study of Engineering Students

A cross-sectional study is currently underway to investigate how students' scores on the SDLRS vary across the four years of undergraduate engineering education. The study will include 400 randomly selected engineering students from first-year through senior year, with equal representation by gender in each set. For more convenient data collection, the instrument has been converted to an on-line form for this study.

The major research question underlying this study is, "what is the trend in the SLDRS scores across the four years of the study?" The desired outcome is that the students' scores will increase as they gain experience in self-directed learning; however, it is possible that putting the students in highly directed learning environments will lead to no change in the scores, or perhaps even a decrease. The second research questions is whether women are affected differently than men in terms of the change in readiness for self-directed learning. It seems possible that the well-documented differences in men's and women's experiences in engineering classes could lead to some differences.¹² Barring unforeseen problems, the results of the study should be available by the end of the first quarter of 2001.

Approaches to Preparing Students to Engage in Lifelong Learning

The final aspect of the on-going study of lifelong learning at Penn State is the implementation of instructional strategies that are expected to enhance students' skills and attitudes related to self-directed learning. Candy summarizes a range of strategies for increasing independence in learning based upon his extensive review of the literature.⁸ These include making use of learner's existing knowledge structures, encouraging deep learning, increasing question asking by the learner, developing critical thinking skills, enhancing reading skills, improving comprehension monitoring, and creating a supportive learning environment. These approaches speak mainly to developing "skills," although the final item addresses developing motivation for learning.

Candy also discusses three broad approaches to implementing these strategies. They are:

1. courses that focus on developing skills that are important to self-directed learning such as information literacy, self-management, and critical thinking, in a context-free manner;
2. approaches that give students opportunities to develop and practice these skills in context;
3. approaches that give students opportunities to develop and practice these skills in context and further seek to make learning itself an object of reflection.

Significant criticism of the first approach has appeared in the literature. Candy notes that the approach has been criticized as being "based upon an inadequate understanding of the complexity of learning." Simply providing students with tools for self-directed learning, such as study skills and time management, is not sufficient to ensure that they can use them effectively in domains of importance to them. This argument leads to the second category of approaches in which the students acquire and practice the skills needed for self-directed learning in an appropriate context. Candy notes that while these approaches are more consistent with the

context-dependent nature of learning, they may still not achieve the desired outcomes. Thus a third approach exists which recognizes the critical role of context, but seeks to make the process of learning itself the object of reflection so that it can be “the object of conscious planning and analysis.” This final approach has three key elements: “the need for the facilitator to take into account the learner’s existing knowledge structures and previous knowledge, the need for the learner to gain an understanding of the syntactic structure of the field that he or she is learning, and the learner’s development of metacognitive awareness or conscious control over his or her learning.”⁸

Which of these three approaches might we as engineering educators use to allow our student to develop the critical skills and attributes? It would appear that second and third approaches, which take into account the importance of context, are the preferred methods. Early work in this area by engineering educators, including Flammer and Fuchs, advocate the use of the second method. Flammer suggested that we “provide more opportunity for students to encounter real-life, open ended problems.” He also points to the need to have our students become comfortable in using the library in their work, presaging the critical area of information literacy for today’s engineers.⁶ This set of skills is critical to the inquiry mode of lifelong learning. Also at the 1979 ASEE conference, Fuchs suggested the use of case studies as one method to develop lifelong learning skills and attitudes.¹² He argues that the case study approach motivates the learner, “teaches learning,” and provides a bridge between the academic world of concentrated learning and the outside world of applying what one has learned.

It is, in fact, the second method that is being implemented in five engineering departments in the College of Engineering at Penn State as part of an NSF Action Agenda Initiative Project. The effects of problem-based learning approaches in two new courses in Industrial and Manufacturing Engineering have been studied using the SDLRS as a pre-test and post-test. The courses are *IME, Inc.* and *Designing Product Families*. *IME, Inc.* is a new two-semester undergraduate course in which multidisciplinary student teams first design and prototype new products, and then produce them in volume. Students must design a marketable product and consider all aspects of manufacturing including process planning, tooling, assembly, and outsourcing--such that they can produce 100-500 units of their product. Additional information about the course can be found in Reference 14. *Designing Product Families* is a new graduate course that is offered jointly in Mechanical Engineering and Industrial and Manufacturing Engineering. The course combines traditional lectures with case studies and collaborative learning activities to introduce students to state-of-the-art methods and tools for mass customization and product family design, including modular design, robust design of scalable product platforms, and product family design metrics. As part of the course, students engage in semester-long projects that implement and test theoretical developments in product family design methods.

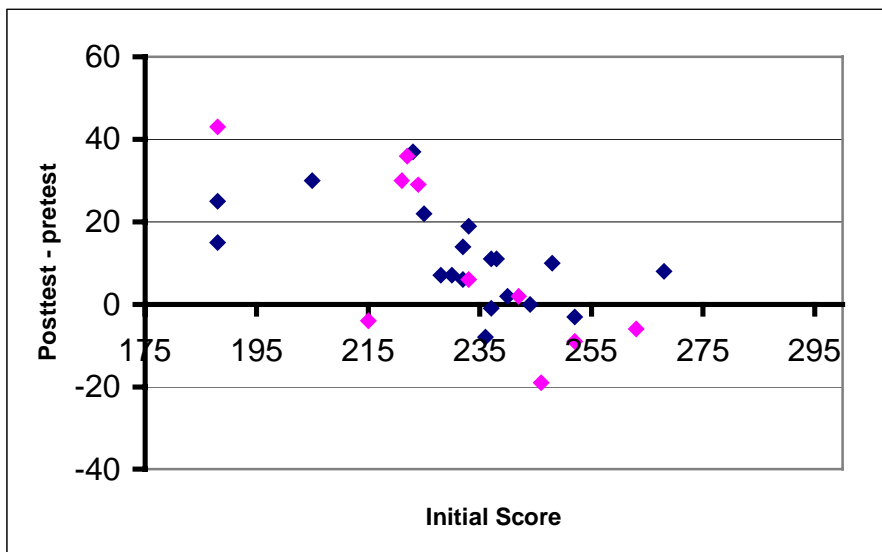
Ten students completed both semesters of *IME, Inc.* and 20 completed the *Designing Product Families* course. One student’s results were removed from the sample prior to analysis. This student showed a decrease of 48 points between the pre-test and post-test. It is believed that the large decrease represents that student’s “re-centering” on the SDLRS instrument based upon experiences in the class with more highly proficient self-directed learners. As a result of the

experience of working with more proficient learners, the student was able to more accurately assess his/her own abilities, leading to a large decrease in score. Analysis of the data supported the conclusion that this student represented an “outlier.” Regression analysis of the results of post-test versus pre-test scores revealed that this student’s results were an unusual observation because of the unexpectedly large residual. Subsequent analysis using a t-test showed that the result could be considered an outlier with $\alpha=0.05$. Therefore, this point was removed from the data set for subsequent analysis of the results. Another indication that this point was an outlier is the fact that the data failed a test for normal distribution of residuals with the point in the data set, but passed it when the point was removed.

Analysis of the pre-test and post-test results from the two projects using ANOVA showed that the changes in the students scores were statistically significant at the 0.05 level, but that the two versus one semester experience did not have a significant effect. This latter result may be influenced by the small sample size and will be revisited in follow-on studies. Subsequent analysis of each of the data sets with the Bonferroni test showed that the pre-test/post-test differences for *Designing Product Families* were significant at the 0.05 confidence level. The results for *IME Inc.* approached significance, but were not significant at the 0.05 level. The lack of significance is very likely influenced by the very small sample size, 10, and is expected to be improved by adding additional students to the pool in future studies.

Figure 2 presents the pre-test/post-test results for the students in the study. As might be expected, students whose initial score is at the lower end make the largest gains. Of the 30 students in the sample, 14 showed substantial gains (defined as 10 points or more) 14 had no change (defined as less than 10 points) and two had a substantial decrease of more than 10 points. The results of the two pilot courses indicate that the students’ readiness for self-directed learning, as measured by the SDLRS, is being positively affected by the experience of engaging in self-directed learning within the two courses, consistent with the expectations based upon the literature. Follow-on studies of these courses will include testing of control groups to allow a more precise assessment of the impact of the new courses on the change in SDLRS scores.

Figure 2. Change in score versus pre-test score for students in problem-based learning classes



Conclusions

The SLDRS scores of Teaching Interns, who are very successful students, showed no correlation with GPA as a measure of academic success. This result is consistent with the literature, which suggests that traditional pedagogical approaches do not enhance self-directed learning skills. The results of the cross-sectional study of engineering students at Penn State using the SDLRS should give additional evidence of the effects of the present teaching approaches on readiness for self-directed learning. Two new courses implemented based upon problem-based learning have shown statistically significant gains in SLDRS scores of the students based upon pre-test and post-test scores. These results suggest that enhancing students' readiness for self-directed learning can be enhanced with this pedagogical approach, consistent with other results in the literature.

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