Assessing Readiness for Self-directed Learning

Thomas Litzinger, John Wise, SangHa Lee, and Stefani Bjorklund

Penn State University

Introduction

The ABET engineering accreditation criteria bring lifelong learning to the forefront for all 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 the accreditation criteria demand that we prepare engineering students to engage in lifelong learning. While this level of emphasis on preparing 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 by telephone in the area of Rockport, IL.[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 Houle[5]: 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. On-going work at Penn State has focused on informal/self-directed learning modes. In particular, the work has been directed at identifying curricular approaches to develop the skills and attributes required for lifelong learning.[6,7,8] In a previous study[8], a new open-ended design-driven course was found to enhance readiness for self-directed learning. However, a cross-sectional study of engineering students in their first through fourth years showed that students' readiness for self-directed learning was independent of their academic standing. This result was surprising since many of the fourth year students were expected to be taking their capstone courses, which typically involve the type of open-ended design tasks that were found to increase readiness for self-directed learning.

To determine the effect of the capstone courses on readiness for self-directed learning and to address the unexpected result in the cross-sectional study, two new studies have been initiated. The first study is a cross-sectional study, which includes students from first to <u>fifth</u> year in an attempt to capture more students who are taking their capstone courses, which should resolve the issues that arose with the earlier study. The second study is a pre-test/post-test study for students in the capstone courses in Mechanical and Electrical Engineering, which will explicitly assess the impact of these courses on students' readiness for self-directed learning. The remainder of this paper discusses the selection of the instrument used in this work and presents the results of the two studies.

Selection of Instrument

In his paper, "Undergraduate Foundations for Lifelong Learning," Flammer [9] 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 recent 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.[10]

Candy, in his extensive review of self-directed learning, summarizes the characteristics of the self-directed learner from many sources.[11] These characteristics fall into two sets, personal attributes and skills, that are analogous to Flammer's "will do" and can do." Candy's lists are:

> <u>"Will do" Attributes</u>: curious/motivated, methodical/disciplined, logical/analytical, reflective/self-aware, flexible, interdependent/interpersonally competent, persistent/responsible, venturesome/creative, confident, independent/self-sufficient.
>
> <u>"Can do" Skills</u>: 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 Guglielmino's Self-directed Learning Readiness Scale (SDLRS), developed in 1978,[12] and Oddi's Continuing Learning Inventory (OCLI), developed in 1984.[13] Candy reports that the SDLRS is the much more widely used of the two instruments.[11] During the development of the SDLRS eight factors were identified that contribute significantly to the ability to engage successfully in self-directed 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.

Evidence of reliability and validity for the SDLRS was recently reviewed and summarized.[14] The reported reliability data for internal consistency are split-half and coefficient alpha between 0.67 and 0.96, and test-retest reliability of 0.79 and 0.82. The validity of the SDLRS has been studied extensively. Some of the evidence cited in the review of the instrument include:

- Content validity: strong congruence between Guglielmino's original Dephi results and an review of the literature on self-directed learning.[15]
- Construct validity: Significant convergent and divergent validity found in five different studies.[16-20]
- Criterion validity: Significant positive correlations reported with learning projects undertaken,[21, 22] with hours spent on self-directed learning,[23] and with observable student behaviors related to self-directed learning.[24]

The review also notes that two papers in the literature criticized the content validity of the SDLRS, [25, 26] but that the criticisms are refuted by other studies. (To put the level of criticism in context it is helpful to note that the SDLRS website[27] lists nearly 200 references in which the instrument was used.) The summary statement from the review of the SDLRS is that it "can be used with acceptable confidence to provide an accurate measurement of readiness for self-directed learning." [14]

Cross-sectional Study of Engineering Students

During the 2000 academic year, a cross-sectional study of students in the College of Engineering at the University Park campus was undertaken.[8] In that study, 400 randomly selected engineering students from semester 1 through 8 were contacted and asked to take the SDLRS instrument on-line. The major research question underlying this study was, "What is the trend in the SDLRS scores across the four years of the study?" The desired outcome was that the students' scores would increase as they gain experience in self-directed learning, particularly in the later semesters when students experience more open-ended problem solving challenges in their elective courses and their capstone experiences. The second research question in the study was whether women and men differ 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[28] could lead to some differences in readiness for self-directed learning. To use the data to address possible gender differences, the random sample of students was balanced for gender.

Of the 400 students who were contacted by email and invited to participate in the study, 145 responded; of those who responded, 79 were female. The results from the 2000 study showed that there were no statistically significant changes in average SDLRS scores among students in their first through eighth semesters. Thus, the expectation that elective courses and capstone courses were leading to enhanced readiness for self-directed learning was not borne out. The study did not show any statistically significant differences between male and female students.

In the new cross-sectional study, the sample was expanded to include students in their ninth and tenth semester of study. The exclusion of these students from the previous cross-sectional study was potentially significant since many engineering students do not complete their studies in eight semesters; their exclusion is a possible explanation for the failure to find any significant increase in SDLRS score in the latter semesters. For this study a gender balanced, randomly selected set of 600 students was created and the students were contacted by email to participate in the study. First and second semester students were over-sampled, because their response rate in the original study was lower than expected.

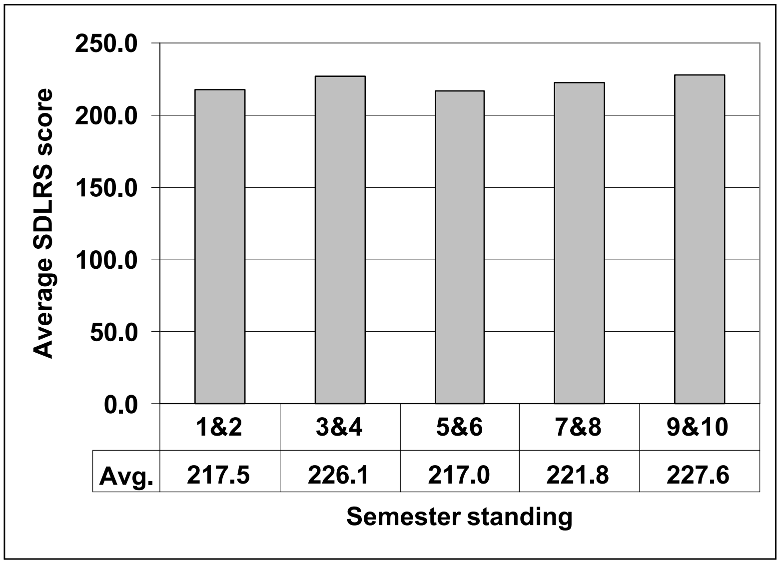
Table 1 presents a summary of the sizes and gender balance of the samples, and of those students who participated in the study. The overall response rate was approximately 30% (174/600), with females participating at higher rate, 34% (101/300) than males, 24% (73/300). About half of the disparity in the response rate between females and males results from students in their first two semesters; excluding them from the comparison gives closer response rates – females: 33%, males: 28%. A review of the responses prior to scoring showed that 22 students did not respond to all items; of these most had only one or two items missing. For these items the mean imputation method was used to complete their responses. One student had many items missing and was eliminated from the analysis. Prior to the use of the mean imputation method, a reliability analysis was conducted, and the Cronbach alpha was found to be 0.91, consistent with values reported in other studies.[14]

Table 1. Sample size, response size and gender composition for 2002 study

Semester standing	Number in Contact Sample	Number Responding	Females	Males
1,2	200	52	35	17
3,4	100	26	11	15
5,6	100	35	18	17
7,8	100	29	18	11
9,10	100	31	18	13
		173	100	73

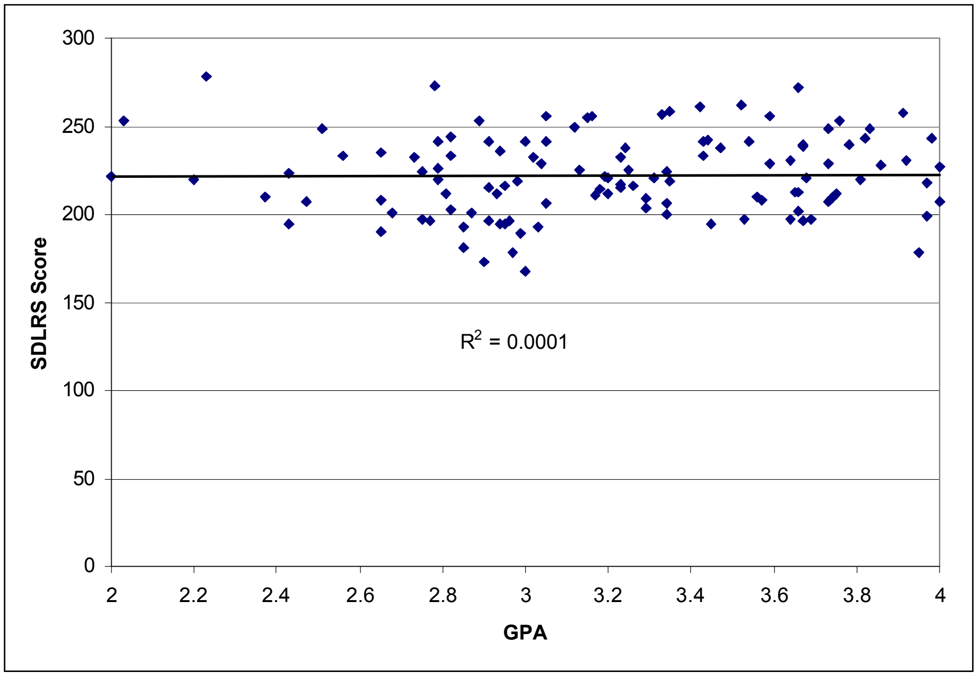
Figure 1 presents the average SDLRS scores for the five groups of students in the study, who were grouped by semester standing according to academic year from first year (1&2) to "super-senior" year (9&10). The average scores range from 217 to 228, corresponding to percentile ranks, based on SDLRS results for adults, of 50% and 68%, respectively. Although the data suggest a slight upward trend, the trend proved not to be statistically significant based upon an analysis of variance (ANOVA). Thus the cross-sectional study did not find evidence of an increase in readiness for self-directed learning, even for students in the later semesters who are taking elective courses and their capstone courses. No statistically significant differences were found in SDLRS score based on gender, consistent with the previous cross-sectional study. In the present study, the average scores for female students was 224, while that for males was 218; however, the difference was not statistically significant, though it approached significance *($t=1.66$, d.f.$=171$, p-value$=0.098$)*. The previous cross-sectional study also showed similar average scores for female and male students.

Figure 1. Average SDLRS score versus semester standing



Another interesting observation that was consistent with results of the previous study was a complete lack of correlation of SDLRS score with GPA. This lack of a correlation may be explained by the fact that most courses do not ask students to use their skills for self-directed learning and as a result course grades do not provide a good indication of students' readiness for self-directed learning. Figure 2 shows a plot of SDLRS score versus GPA for all students except those in their first semester, since they do not yet have a GPA. The trend line and correlation coefficient in the chart show that in this case that was a complete absence of correlation. For the complete sample, the female students had a slightly higher average GPA than the male students, 3.18 versus 3.10; however, the difference was not statistically significant.

Figure 2. Correlation of SDLRS score with GPA



Pre-test/Post Test Study in Capstone Courses

To more explicitly address the hypothesis that the open-ended problem-solving that is required in capstone courses will lead to an increase in readiness for self-directed learning, and therefore in SDLRS score, students taking the capstone courses in Mechanical and Electrical Engineering were also asked to take the SDLRS. To minimize the disruption of the normal flow of these classes, the instrument was provided on-line, and the students were sent an email from their instructors asking them to complete the instrument. The students received the request to take the pre-test in the third week of class after their project teams were formed.

Of the 81 Mechanical Engineering students enrolled in the capstone course, 36 completed the pre-test. The Mechanical Engineering students can choose between capstone courses that emphasize mechanical or thermal systems. Typically students prefer the mechanical systems course by 3 or 4 to 1, so there are more students in the mechanical systems capstone. In the pre-test, 10 ME students who completed the survey were in the thermal systems capstone, while 26 were in the mechanical systems capstone. The average score for students in the thermal systems capstone was 241, corresponding to the 83rd percentile in the nationally normed results for the SDLRS, and for those in the mechanical systems capstone it was 212 or 44th percentile. This difference is statistically significant at a 95% confidence level *(t=2.46, d.f.=6, p-value=0.049).* Of the 49 Electrical Engineering students, only 8 completed the pre-test. For the Electrical Engineering Students, the mean score was 236, corresponding to a percentile rank of 77%.

In the thirteenth week of the semester, those who had consented to take the pre-test, a total of 51 students, were sent an email asking them to complete in the instrument again. The students were sent follow-up request after the end of the semester in an attempt to increase the response rate; however, only a few additional students responded. Overall the response rate was less than 50% with 24 responding out of the 51 who were contacted. Table 2 presents a summary of the results for the pre-test and post-test scores for each group along with the percentile rank of the average scores based on the nationally normed results for the SDLRS.

Table 2. Results of Pre-test/Post-test in Capstone courses

	Number contacted	**Number Responding**	**Average pre-test score**	**%ile rank**	**Average post-test score**	**%ile rank**
EE Capstone	12	6	238.1	*82*	244.5	*87*
ME – Thermal	11	6	248.7	*90*	248.3	*90*
ME-Mechanical	28	12	214.1	*48*	226	*64*
Total sample	51	24	228.7	*72*	236.2	*78*

While there are intriguing trends in the pre-test/post-test results, an ANOVA shows that the trends do not rise to the level of statistical significance. In particular, the average score for the ME-mechanical systems students increased by 12 points corresponding to a jump from 48th percentile to 64th percentile, a substantial change; however, it was not significant (*t=1.46, d.f.=22, p-value=0.16*). The small sample size is clearly a problem in this study. The differences among the classes evident in the pre-test persisted in the post-test, and the trend was statistically significant with p=0.002 in the ANOVA. No hypothesis can be offered at this time to justify the difference observed in the two different ME capstone courses. The expectation prior to collecting the data was that the students in the two courses would be quite similar in the characteristics including the SDLRS scores.

Conclusions

The goals of this study were to determine whether students' readiness for self-directed learning increases as they proceed through an undergraduate engineering program and to determine whether capstone courses increase their readiness for self-directed learning. A related goal was to determine if there are any gender differences in readiness for self-directed learning. The cross-sectional study showed no statistically significant increase in SDLRS scores. This result suggests that most courses that students take in the undergraduate engineering programs do not ask them to undertake tasks that increase their readiness for self-directed learning. No gender differences were present in the cross-sectional study. Although some of the data show an increase in SDLRS scores between a pre-test and post-test in capstone courses in Mechanical and Electrical Engineering, the results failed to support the hypothesis that the complex problem solving required in these courses would lead to increases in readiness for self-directed learning. The lack of a statistically significant increase in SDLRS scores is of concern in an era when lifelong learning is more critical than ever for engineers. The results of the present study will be extended in future work to increase the sample size in the pre-test/post-test study and to document carefully the type of activities that the capstone courses require the students to undertake.

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. EEC-9973002. Any opinions, findings, and conclusions or recommendations presented in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. The American Society for Engineering Education Goals Committee, E.A. Walker, Chair, "Goals of engineering education; final report of the goals committee," *Journal of Engineering Education*, vol. 58, pp. 367-446, 1968.
2. Panel on Continuing Education, "Engineering education and practice in the United States - Continuing Education of Engineers," National Research Council Committee on the Education and Utilization of the Engineer, Washington, D.C. 1985.
3. N. K. Ovesen, *Advances in continuing education of engineers*. PARIS: UNESCO, 1980.
4. R. M. Cervero, J. D. Miller, and K. H. Dimmock, "The formal and informal learning activities of practicing engineers," *Engineering Education*, vol. November, pp. 112-116, 1986.
5. C. O. Houle, *Continuing Learning in the Professions*. San Francisco: Jossey-Bass, 1980.
6. Marra, R., K. Camplese, and T. Litzinger, Lifelong Learning: A Preliminary Look at the Literature in View of EC 2000, 1999 FIE Conference, San Juan, Puerto Rico, November 1999.
7. Litzinger, T. and R. Marra, Life Long Learning: Implications for Curricular Change and Assessment; ASEE Annual Conference, St. Louis, Mo, June 2000.
8. Litzinger, T., J. Wise, S. H. Lee, T. Simpson, T. and S. Joshi, "Assessing Readiness for Lifelong Learning;" ASEE Annual Conference, Albuquerque, NM, June 2001.
9. G. H. Flammer, "Undergraduate foundations for lifelong learning," presented at Career Management Life Long Learning: ASEE Annual Conference, University of British Columbia, 1978.
10. D. R. Garrison, "Self-directed learning: Toward a comprehensive model," *Adult Education Quarterly*, vol. 48, pp. 18-33, 1997.
11. P. Candy, *Self-Direction for Lifelong Learning: A Comprehensive Guide to Theory and Practice*. San Francisco: Jossey-Bass, 1991.
12. L. Guglielmino, "Development of Self-Directed Learning Readiness Scale," Athens: University of Georgia, 1977.
13. L. F. Oddi, "Development and validation of an instrument to identify self-directed continuing learners," *Adult Education Quarterly*, vol. 36, pp. 97-107, 1986.
14. *Commissioned Reviews of 250 Psychological Tests,* Maltby. J., Lewis, C., and Hill, A., Editors, Edwin Mellen Press, Wales, U.K., 2000.

15. Finestone, P., A construct validation of the Self-Directed Learning Readiness Scale with labour education participants (Doctoral dissertation, University of Toronto, 1994). *Dissertation Abstracts International*, 46, 5A, 1984.
16. Delahaye, B. L. & Smith, H. E., The validity of the Learning Preference Assessment. *Adult Education Quarterly*, 45,159-173, 1995.
17. Long, H. B., & Agyekum, S. K., "Multitrait-multi-method validation of Guglielmino's Self-Directed Learning Readiness Scale," Proceedings of the Twenty-fifth Annual Adult Education Research Conference, 1984.
18. Posner, F. G., A study of self-directed learning, perceived competence and personal orientation among students in an open alternative high school (Doctoral dissertation, University of Denver, 1989). *Dissertation Abstracts International*, 51, 813, 1990.
19. Russell, J. W., Learner preference for structure, self-directed learning readiness and instructional methods (Doctoral dissertation, University of Missouri). *Dissertation Abstracts International*,49, 1689, 1988.
20. McCune, S. K., & L. M. Guglielmino, Validity generalization of the Self-Directed Learning Readiness Scale. In H. B. Long & Associates, *Self-directed learning: Consensus and conflict* (pp. 147-154) Norman, OK: Oklahoma Research Center for Continuing Professional and Higher Education, 1991.
21. Hall-Johnson, K., The relationship between readiness for self-directed learning and participation in self-directed learning (Doctoral dissertation, Iowa State University). *Dissertation Abstacts International*, 46, 7A. 1991.
22. Hassan, A. J., An investigation of the learning projects of adults of high and low readiness for self-direction learning (Doctoral dissertation, Iowa State University). *Dissertation Abstracts International*, 42, 3838A-3839A, 1981.
23. Graeve, E. A., Patterns of self-directed learning of registered nurses (Doctoral dissertation, University of Minnesota). *Dissertation Abstracts International*, 48, 820, 1981.
24. Jones, J. E., Validation study of the Self-Directed Learning Readiness Scale with a sample of adult visual art students. In H. B. Long and Associates, Self-directed learning: Application and research (pp. 131-146). Norman, OK: Oklahoma Research Center for Continuing Professional and Higher Education, University of Oklahoma, . 1992)
25. Bonham, L. A., "Guglielmino's Self-Directed Learning Readiness Scale: What does it measure?," *Adult Education Quarterly*, 41, 92-9, 1991.
26. Field, L., "An investigation into the structure, validity, and reliability of Guglielmino's Self-Directed Learning Readiness Scale," *Adult Education Quarterly*, 39, 125-39, 1989.
27. Guglielmino & Associates, http://www.guglielmino734.com/prod01.htm, March 2003.
28. E.J. Whitt, M.I. Edison, E.T. Pascarella, A. Nora, and P.T. Terenzini, "Women's Perceptions of a "Chilly Climate" and Cognitive Outcomes in College: Additional Evidence, *Journal of College Student Development*, vol. 40, no. 2, pp. 163-177, 1999.

THOMAS A. LITZINGER
Thomas A. Litzinger is currently Director of the Leonhard Center for the Enhancement of Engineering Education and a Professor of Mechanical Engineering at Penn State, where he has been on the faculty since 1985. His work in engineering education involves curricular reform, teaching and learning innovations, faculty development, and assessment. He may be contacted at tal2@psu.edu.

JOHN WISE
John Wise is Director of Engineering Instructional Services at Penn State. In this capacity, he provides assistance to faculty members and teaching assistants in the areas of teaching, learning, and instructional technology. He received his B.A. in Liberal Arts from The University of the State of New York and his M.S. and Ph.D. in Instructional Systems from Penn State. He may be reached at jwise@psu.edu.

SANGHA LEE
SangHa Lee is a doctoral candidate in Educational Psychology at Penn State. He earned his M. Ed. and B.S. in Mathematics Education from the Korea National University of Education and taught mathematics in Korea for eight years.

STEFANI BJORKLUND
Stefani Bjorklund is a graduate student in Higher Education at Penn State who is currently working in the Leonhard Center as part of the assessment team. Prior to joining the Leonhard Center she was employed by the Center for the Study of Higher Education at Penn State as part of the team that performed the assessment of the ECSEL coalition.