Experiential Learning Environments: Do They Prepare Our Students to be Self-Directed, Life-Long Learners?

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ABSTRACT

Recent research indicates that traditional academic structures may not effectively promote self-directed learning. We investigated whether an experiential interdisciplinary projects program, called the Global Studies Program, increased readiness for self-directed learning (SDL) and life-long learning (LLL) using three methods: a nationally recognized course evaluation system called the Individual Development and Educational Assessment system (IDEA); an internal student project quality assessment protocol; and the Self-Directed Learning Readiness Scale (SDLRS).

Student self-assessments through the IDEA system showed Global Studies Program students reported much greater progress in LLL-related skills than did national and local comparison groups. Similarly, review of student projects by independent faculty teams found Global Studies Program students consistently outscored on-campus project students in LLL-related measures by wide margins. The SDLRS also showed a positive, but less emphatic increase in SDL readiness among a Global Studies Program cohort. The research demonstrates the success of one experiential learning environment in promoting SDL/LLL, while raising interesting issues regarding alternative methods of measuring potential benefits.

Keywords: experiential programs, life-long learning, self-directed learning

I. INTRODUCTION

In recent years, most engineering schools have sought to complement the traditional focus on student attainment of immediately-measurable skills, abilities, and knowledge with less easily defined and assessed preparation to become self-directed, life-long learners. Recent research indicates that traditional academic structures may not effectively promote self-directed learning [1–3]. A significant thrust in education for LLL are nontraditional, experiential acade-mic programs often emphasizing more open-ended, self-directed, and/or socially and culturally embedded research experiences. Assessing how such experiences affect student intellectual development is difficult, however, because the qualities of interest are complex (what exactly is "self-directed" learning?) and, by definition in the case of life-long learning, only latent within students. Not surprisingly, evidence of the success of LLL curricula is largely anecdotal or superficial.

In this study, we analyzed the effectiveness of one well-regarded experiential academic program, the Worcester Polytechnic Institute (WPI) Global Studies Program (Global Program), in preparing students for life-long learning through the acquisition of attitudes and skills supportive of self-directed learning (SDL). Three complementary assessment methods were used, resulting in both convergent and somewhat divergent results: assessments by both students and independent faculty members clearly found the WPI Global Program improved most students' development of core SDL-related capacities, yet the broadest test of SDL readiness suggested outcomes that were both more variable and less dramatic on average. We explore differences among sub-populations in this latter measure and discuss differences among these alternative measures of SDL/LLL that might account for their somewhat divergent results. In doing so, we hope to better understand the potential effectiveness of experiential educational programs on self-directed and life-long learning, while also illuminating methodological issues related to assessing the impact of discrete educational programs on such complex human development phenomena as SDL and LLL.

II. BACKGROUND

A. Conceptualizing and Assessing SDL and LLL

LLL "suddenly" became part of engineering education when ABET included it as one of its desired learning outcomes. Most schools have had trouble defining LLL, and nearly all have trouble measuring it. Many have resorted to outcomes descriptors that relate to information finding abilities, elective course decisions, and participation in professional societies. Despite these outcomes being desirable, they are somewhat superficial, low-level abilities. Other methods to probe LLL involve using post-graduation paths and career choice data that are obtained by alumni surveys with low response rates. A rigorous approach says that LLL cannot be measured until someone has actually had a life. At present, the best we can do in undergraduate education is to place students in learning environments expected to be conducive to developing LLL-related

skills, while investigating alternative methods for assessing whether in fact these measures are effective.

The literature clearly indicates that preparation for LLL involves complex, deep learning issues. Its definition is much broader than simple information gathering traits. Very often the term "self-directed learning" is used. Oliver suggests LLL is self-actualized learning demonstrated through continuous personal development [4]. Brockett and Hiemstra suggest that SDL "is the ability and/or willingness of individuals to take control of their own learning that determines their potential for self-direction" [5]. We recognize that strict definitions of LLL and SDL will have overlapping and distinct parts. Areas of significant overlap include critical thinking, research skills (particularly regarding information use, retrieval, and synthesis), and basic interpersonal skills (communication). Hence, probing students' ability to engage in LLL and assessing their skills and attitudes in SDL should involve multiple measures.

One investigation of effective self-directed learning defines it 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." SDL is exemplified by *attitudes* like "curious/motivated, methodical/disciplined, logical/analytical, reflective/self-aware, flexible, interdependent/interpersonally competent, persistent/responsible, venturesome/creative, confident, independent/self-sufficient"; and *skills* like "highly developed information seeking and retrieval skills, have knowledge about and skill at the learning process, develop and use criteria for evaluating [critical thinking]" [6]. Candy frequently discusses the social context of learning and that SDL should not necessarily be solely independent [6]. Meaningful dialogue and discussion are needed to clarify ideas and hear other points of view. Interpersonal competence includes communication skills and "reporting what he or she has learned in a variety of ways" [7].

Besterfield-Sacre and colleagues [8] nicely explicated the ABET LLL learning outcome (recognition of the need for, and an ability to engage in life-long learning) within a framework of Bloom's taxonomy. The outcome elements include a range of abilities such as basic communication skills, developing learning plans, dealing with information including evaluating integrated information, and critical thinking. To summarize: the ability to engage in LLL begins with a student-demonstrated *readiness for* SDL.

As educators our interests involve what we do with our students for four years and how that prepares them professionally, intellectually, and emotionally for post-graduation life. Because of its many dimensions it is important to understand LLL, or students' preparedness for LLL, and its connection to the curriculum. Few studies have really probed this connection. Alverno College pioneered work in this area related to liberal arts education, and their results clearly indicate that experiential learning is persistent [9]. However, their methodologies (longitudinal "perspective" and "behavioral event" interviews) are beyond the scope of this work. Other appropriate methodologies like alumni surveys are plagued by poor response rates and lack of control for confounding variables that affect post-graduation learning. An evaluation that measures student preparedness for LLL while in college could be used to better connect academic structures and student development in the dimensions described above.

Several engineering schools have implemented nontraditional curricula on a broad scale (WPI, Rose-Hulman, Harvey Mudd,

Olin College). Other universities have incorporated new academic structures such as project-based courses, service learning, off-campus internships, international programs, and cooperative education. Many study abroad programs are implementing experiential educational experiences. These programs' goals include improved student learning, particularly in dimensions related to LLL. Engineering educators could benefit from knowing the answer to a relatively simple question: *Do experiential academic structures result in increased readiness for self-directed learning?* This work sought to answer that question for one type of structure using three complementary methodologies. The results would augment and complement those of Litzinger [1, 2] and would inform curriculum development in the engineering community.

B. The WPI Global Studies Program

Thirty years ago WPI implemented nontraditional instructional design, emphasizing project-based education to, among other things, better prepare students for life-long learning. Currently large numbers of students, 350 per year, travel internationally to complete projects that link technology and society. The off-campus portion of this activity is the credit equivalent of three courses. Prior to sojourn, all students must complete 1 $^1/_2$ courses worth of site and project-specific preparation work (4.5 credit hours). The preparation phase is two months on-campus and the project phase is two months off-campus, thus total time is one semester. During the first two months students have other courses and activities, but once they leave WPI (the second two months) they work full-time on their project. The total preparation and sojourn experience is thus equivalent to 4.5 courses (13.5 credit hours). Students travel in groups of 24 with one or two faculty advisors to the international site. On-site work involves teams of three or four students working full-time for local agencies. Sponsors provide the topic, but student teams develop objectives, conduct a literature review, identify appropriate methods, conduct the research, and analyze and interpret the results. All teams produce a final report that is graded for academic credit and teams deliver a formal final presentation to their agency. A typical project could have a computer science major, a mechanical engineering major, and a chemistry major working on low-cost sustainable housing improvements for shack dwellers in Namibia; advised by a management faculty member and sponsored by the Namibian Renewable Energy Bureau.

Although space prevents a review of the literature on international programs and student learning, most educators assume that off-campus sojourns have positive effects on student learning, particularly dimensions such as those involved in LLL. Because WPI aims to prepare students for LLL, and it sends so many students off-campus to do significant amounts of nontraditional, non-classroom based work, an opportunity existed to measure growth in SDL readiness in a large sample.

C. Assessment Options

In order to assess whether WPI's Global Program is increasing the propensity of students to engage in life-long learning, and to do so *anticipatorily* (i.e., while the students were still students), we chose three methods by which to investigate gains made in SDL skills and attitudes recognized as pre-cursors to LLL. The first two methods involved student self-assessment; the third, faculty assessment of student work. Each of these methods is described below, followed by a brief discussion of how we used them to

achieve a triangulated research methodology with complementary insight.

1) Self-Directed Learning Readiness Scale Instrument: There are two major instruments for assessing students' preparation to engage in LLL and their willingness to do so. They are the Self-directed Learning Readiness Scale (SDLRS), and the Continuing Learning Inventory (CLI). We chose the SDLRS because the literature indicates it is the most studied and used. The SDLRS is a 58-item, Likert-scaled questionnaire available from Guglielmino and Associates [10]. The prompts probe student attitudes toward learning. Included are items such as self-generation of knowledge, responsibility for learning, individual vs. group learning, curiosity about learning, learning environment preferences, study skills, and the importance of continual learning. SDLRS validity has been demonstrated in scores of studies and contexts, particularly with studies correlating SDLRS scores and observable student self-directed learning behaviors [1].

At two recent ASEE meetings Litzinger [1, 2] presented studies of engineering students' readiness for SDL. This work showed that traditional engineering education (over four years) including capstone design courses had little positive effect on SDLRS. His conclusions were 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" [2].

2) IDEA System Student Ratings of Instruction: To supplement the SDLRS analysis, we used secondary data obtained through the Individual Development and Educational Assessment Student Ratings of Instruction System (IDEA), a course evaluation product of the IDEA Center at Kansas State University designed to focus on student learning, "[r]ather than emphasizing the instructor's teaching techniques or personality" [11]. Key learning metrics include student progress on learning objectives determined by the instructor to be "essential" or "important" to each particular course, as assessed through the familiar end-of-course, anonymous student course evaluation and self-assessment of progress. The IDEA System is widely used. For example, between August 1998 and August 2001, the IDEA System was used to assess student learning in more than 70,000 classes at 122 institutions varying widely with respect to size, location, degrees granted, public/private, etc [12]. Student self-reports of progress on key learning objectives measured through the IDEA system have been shown to be valid measures of student learning and development [11, 13].

Instructors are advised to select three to five objectives from the IDEA System's list of 12 possible learning objectives. For the WPI project experience, three learning objectives closely related to SDL development were identified as *important* or *essential* outcomes of the preparation phase. These objectives were *Research Skills* ("Learning how to find and use resources for answering questions and solving problems"); *Critical Thinking* ("Learning to analyze and critically evaluate ideas, arguments, and points of view"); and *Expression* ("Developing skill in expressing oneself orally or in writing").

For each of these three SDL dimensions, the success of the preparation courses was assessed against two comparison groups comprised of courses that also targeted the same learning objective: all those at WPI and all those nationally in the IDEA system database. Our primary comparison groups were the three WPI groups (one for each objective), as these results were drawn from the same general student population as that of the preparation courses, in contrast to the institutionally diverse IDEA groups.

3) Faculty Review of Project Reports: In any assessment analysis it is important to collect data that represent actual student outcomes in addition to student perceptions or other indirect measures. In our educational process there are two major outcomes: the project team's final presentation and final written report. Analysis of presentations at sites all over the globe was not feasible but analysis of final reports was possible.

Periodically, WPI evaluates all reports produced by student teams completing the technology-society project. This is about 200 reports each year, both on and off-campus. The evaluation uses an internally developed instrument with trained and calibrated reviewers [14]. This is not the grade that students received. It is an independent assessment of project outcomes accomplished by reading final project reports and applying our evaluation rubrics.

There are four questions on the 35-question evaluation form that relate to SDL/LLL assessment. One question probes "the extent to which the students acquired and applied knowledge not obtained from prior course work." The rubrics for this prompt are as follows: (1) *excellent*—the project contains an extensive, critical literature review on a topic and makes extensive and effective use of recognized, respected, and appropriate methodologies not likely to have been covered in the students' coursework; (2) *acceptable*—the project contains an acceptable literature review on a topic and makes significant use of appropriate methodologies not likely to have been covered in the students' coursework; and (3) *poor*—the project makes only very limited use of background knowledge or methodologies not likely to have been covered in the students' coursework. This item probes what information was retrieved, how it was synthesized, and how well it was integrated into the project report. Because the projects are multidisciplinary and do not depend upon discipline-specific knowledge, application of the rubric can provide evidence regarding one dimension of LLL. Similarly, three other items in the evaluation form probe evidence for research skills, critical thinking, and communication—all abilities related to SDL.

4) Research Triangulation: Combined, these three methods offered complementary windows on complex SDL/LLL phenomena. The SDLRS is a well-regarded, standardized assessment tool designed specifically to measure SDL, and was applied immediately before and after the full 14-week Global Program project experience (Figure 1). The IDEA system is also a well-regarded instrument for measuring student progress on various learning objectives, including a number closely related to SDL. Where the SDLRS measures change in student self-perception from the beginning to the end of the learning experience, the IDEA system data reflect student perceptions of their progress on SDL indicators halfway through the experience, upon completion of the required Global Program preparation designed, among other things, to help students work effectively as individuals and in small teams to research and complete open-ended, self-directed projects while abroad. Student responses are compared not to their own responses prior to the learning experience, but rather to those of other students at WPI and nationally enrolled in courses that sought to enhance student performance on the same SDL-related learning objectives. Lastly, the independent review of completed project reports by WPI faculty provided evidence other than student perception as to the degree to which the Global Program students demonstrated qualities of critical thinking and self-directed knowledge acquisition in comparison with their on-campus counterparts.
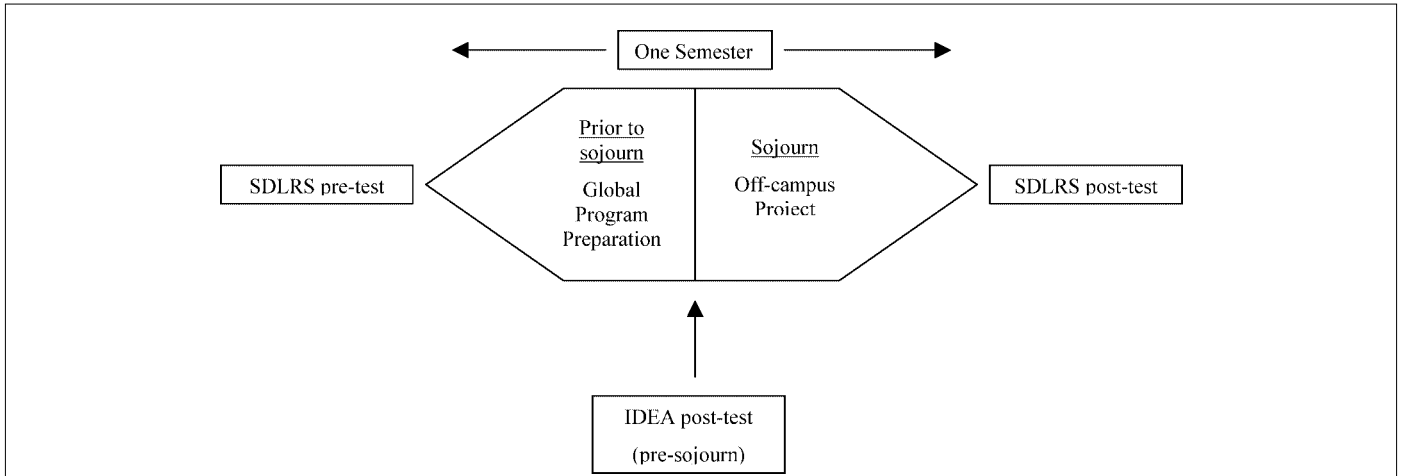
Figure 1. Schematic of methodology implementation.

	All Respondents			Paired Surveys Group		
	Pre-test	Post-test	Change	Pre-test	Post-test	Change
Mean	218.2	220.4	2.2	219.4	222.7	3.3
Standard Deviation	22.8	25.0		24.1	24.9	
N =	259	198		107	107	
Response Rate	93%	71%		38%	38%	

Table 1. Comparison of SDLRS analysis groups.

Whether using one or three methods, it remains a daunting challenge to assess the effect of a single educational program unfolding over only four months on complex human development phenomena such as self-directed and life-long learning. Research triangulation allows complex phenomena to be studied using different lenses, none of which are perfect nor perfectly comparable to one another. Throughout the paper, we discuss technical and conceptual strengths, weaknesses, and issues we see pertaining to each of the methods used here.

III. METHODOLOGY

A. SDLRS Methodology

We implemented the SDLRS instrument over the entire student cohort that went off-campus during the 2003-4 academic year and the following summer. We have four preparation-sojourn cycles during a calendar year. The pre-test was conducted at the first meeting of each of the twelve separate preparation courses, and with a "captive audience" we were able to obtain 259 pre-tests and a high completion rate (93 percent). The post-test was conducted as each student team completed their project at one of our twelve different off-campus locations throughout the world. On-site project advisors supervised SDLRS application and data collection. Obtaining a high completion rate (71 percent) for the post-test was more difficult since student teams are in the field during their sojourn and are extremely busy during the end of the project, completing final reports and giving final presentations to their sponsors. Finally, although the surveys were completed

anonymously, we were able to use unique demographic data within the survey to create an analysis group comprised of 107 individuals for whom we had paired pre- and post-test data. We used this "paired survey" group to conduct the pre-post test analysis of SDLRS scores because it allowed certainty with respect to analyzing change in individuals' SDLRS scores and permitted use of a preferred paired samples t-test. While use of the paired survey group resulted in a lower effective response rate (38 percent), a comparison of the paired survey group to the entire sample reveals little difference between them, suggesting non-response bias is not a problem (Table 1). In all cases, we excluded improperly coded response sheets and those with more than four missing responses. We coded for gender, age, and project site. Following completion of all post-tests, the results were sent to Guglielmino and Associates for analysis. To our knowledge, this study is the largest examination of SDLRS scores for predominantly technically-oriented students enrolled in a non-traditional or experiential academic program.

B. IDEA System Methodology

All data used for this method were derived from IDEA System Group Summary Reports. We implemented the IDEA course evaluation form at the completion of nine pre-sojourn Global Program preparation classes. This meant students had worked in small teams to research and write a project proposal, and had acquired some site-specific cultural training, but had not yet left campus for their project work. The total number of student respondents from the nine Global Program preparation classes studied was 184, a reasonable basis for analysis. We also cross-checked the 2003-04 test

year preparation course data with that from 2004-05 (representing a different cohort) and obtained similar results.

We compared student progress on each of the three SDL/LLL-related learning objectives for the Global Program preparation with all courses at WPI and in the IDEA System national database that had targeted the same learning objectives. The WPI group included data for each learning objective from more than 5,000 students and an average of 241 classes, while the IDEA groups averaged almost 18,000 classes. For the two-year test period studied, a significant fraction of classes in both comparison groups pursued the same learning objectives (WPI/IDEA): *research skills* 38 percent/41 percent, *oral and written expression* 45 percent/46 percent, and *critical thinking* 43 percent/49 percent [12]. Thus, we were able to compare results of the Global Program students against two large comparison groups. As noted above, we are principally interested in comparisons with other WPI courses, as these are drawn from a common student population, hence differences in progress on the learning objectives are likely to relate to differences between educational approaches rather than to differences in student populations (e.g., between our technically-oriented students and others in the national IDEA database).

C. Faculty Review Methodology

The methodological details of our internal review of all reports completed during a calendar year are described elsewhere [14]. The review takes place in the summer, following the completion of four preparation-sojourn cycles. We extracted the data specifically related to LLL from reviews completed during the summers of 2002 and 2004. The off-campus cohorts were compared to the on-campus cohorts.

The discussion section considers methodological differences and limitations and their potential effect on study results, but a few points are worth noting here. For one, the unit of analysis of the faculty review is the project team rather than the individual student, and thus, strictly speaking, it would be an ecological fallacy to attribute LLL gains demonstrated in the team report equally to all students in the team. However, because teams are small and individual project contributions are tracked by faculty advisors, we believe these assessments of team accomplishment offer insight into the experience of individuals composing the teams.

Another concern with the faculty review is that differences observed between the final reports of Global Program students versus on-campus project students might reflect pre-existing differences among these groups in attributes such as adventurousness or openness to new experiences that might relate to SDL/LLL. Unfortunately, logistical constraints and the nature of the program precluded controlling for such biases in the student population. We do know that the two groups vary only marginally in GPA. Global program participants have an average GPA of 3.7, while non-participants had an average of 3.5. Further, institutional efforts to understand and address the significant performance differences reported below suggest a significant contributor to differences in learning outcomes are structural differences between the on- and off-campus programs, particularly that all off-campus students complete the preparation course discussed here and participate in projects that are sponsored by external agencies, providing students professional working environments and opportunities to "contribute to society" often lacking in on-campus work. Better understanding of these matters is clearly desirable.

IV. RESULTS

A. IDEA System Results

The data used to assess the effectiveness of the Global Program preparation in meeting the SDL and LLL related learning objectives against other courses nationally and at WPI was from self-reported student assessments of development on a five-point scale ("My progress on this objective was" 1 = Low, 5 = High). For all three objectives analyzed, the average student responses were IDEA system 3.8 (+/− 0.1), WPI 3.6, and the Global Program preparation 4.3 as shown in Table 2. In all cases, average ratings were substantially higher for the Global Program preparation than for WPI as a whole.

To understand the significance of differences in means between traditional WPI courses and the preparation phase of the experiential program, Table 3 shows for each learning objective how these means rank compared against all other classes in the IDEA system national database that targeted the same educational outcome. The differences are dramatic. On average, the Global Program preparation courses ranked in the 67th percentile of all courses seeking to develop student capacities for research skills, critical thinking, and expression, far higher than the 29th percentile average of all WPI classes seeking these outcomes.

Another way to analyze collective student progress is to consider the frequency with which students report meeting certain thresholds of progress. Figures 2 to 4 show for each objective and each population the percentage of classes that reached three average ratings thresholds (3.50, 3.75, and 4.00 on the five-point scale described above). Figure 2, for example, shows that student research skills ratings averaged at least 3.5 in all (100 percent) of the Global

Objective	Global Program Preparation	WPI	IDEA
Research Skills	4.2	3.5	3.7
Critical Thinking	3.9	3.5	3.8
Expression	4.3	3.5	3.8
Average	4.1	3.5	3.8
No. of Classes (avg)	9	241	17,941
No. of Students	184	5000+	

Table 2. Comparison of average student responses from IDEA course evaluations.

Objective	Global Program Preparation	WPI
Research Skills	78	32
Critical Thinking	48	25
Expression	75	29
Average	67	29

Table 3. Student progress on learning objectives: Global Program preparation vs. WPI. Ranking of mean class rating in IDEA System National Database (Percentile).
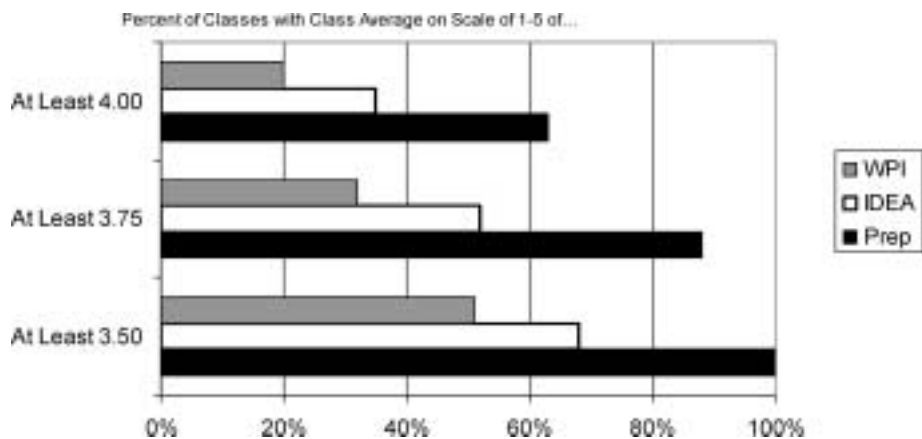
Percent of Classes with Class Average on Scale of 1-5 of...

Figure 2. Research skills: student ratings averages.

Percent of Classes with Class Average on Scale of 1-5 of...

Figure 3. Critical thinking: student ratings averages.

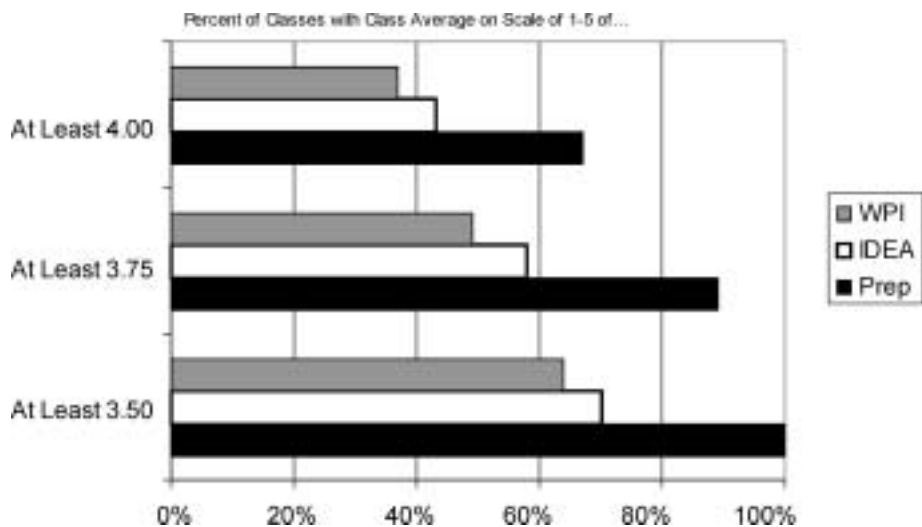Percent of Classes with Class Average on Scale of 1-5 of...

Figure 4. Expression: student ratings averages.

Program preparations, twice the WPI average and appreciably more than the 70 percent rate for all IDEA courses. In all cases, ratings were substantially higher for the Global Program preparation than for WPI as a whole.

One key to these comparatively high ratings was the degree to which the Global Program succeeded in improving the SDL-related abilities of many student participants. Of the nine preparation classes assessed, all achieved an average student response of

	Off-campus	On-campus
2004 Results		
N =	35	62
Ave rating for LLL item (scale of 5)	3.9	2.7
Reports rated below acceptable	3%	44%
Overall Quality Rating	3.6	2.4
Additional Results on Items Related to SDL		
Research skills	3.6	2.5
Critical thinking	3.5	2.3
Communication: written and visual	3.7	2.8

Table 4. Results of final report analysis for two recent evaluation periods (the rating scale is 1 to 5 with 1 = Poor, 3 = Acceptable, and 5 = Excellent).

3.5 or greater on all three objectives, save for one class on one objective. These data indicate the project preparation experience strongly improves student acquisition of core SDL capacities, both deeply (individual gains are sizable) and broadly (most students benefit).

B. Faculty Review Results

Table 4 summarizes the results from the 2004 final report evaluation cycle. The sample size is somewhat lower than the total SDLRS numbers because we analyzed only a random sample of final reports to reduce expenses. Note that there are three or four students per team and sample sizes represent numbers of teams. The numerical rating score is 1 = Poor (or absent), 3 = Acceptable, and 5 = Excellent. The 2004 results are from the same off-campus cohort reported above. We have data for several years that show the same result. That is, that the off-campus project experience provides better evidence of LLL abilities (in the dimension assessed) than the on-campus experience. For example, in 2002 the off-campus average for the LLL item was 4.1 while that for on-campus was 3.1. Off-campus cohort averages are consistently higher than on-campus and there is a striking difference in the percentage of reports rated "below acceptable".

Also shown in Table 4 are the overall quality ratings. This rating is a summary evaluation of all project aspects: *objective definition, literature synthesis, methodologies, data collection, results and analysis, writing and presentation quality*, and *overall depth*. The differences between off and on-campus projects are clear, and as with the IDEA results, suggestive of substantial benefits accruing to a large fraction of students in the study-abroad program.

Table 4 also shows results from three items related to SDL, and like the LLL item, off-campus students consistently out-perform those on-campus. Research skills include relevant literature reviewed, understood, and synthesized; and appropriate choice and application of methodology. Critical thinking involves rigorous analysis of results with conclusions grounded in sound interpretation, while communication evaluates the written and visual quality of the report.

	Pre-SDLRS	Post-SDLRS	Change
Mean	219.4	222.7	3.3
Standard Deviation	24.1	24.9	18.1
t	1.89		
p	0.06		
N =	107		

Table 5. SDLRS paired survey results for Global Program cohort.

C. SDLRS Results

Test results shown in Table 5 indicate the Global Program project experience had a modest, positive effect on students' readiness for self-directed learning, with average pre/post scores increasing 3.3 points, statistically significant at the $p = 0.06$ level. The distribution of pre/post score changes shows that for many students (43 percent), the experience resulted in relatively small changes (< 10 points) in SDL readiness, and the overall effect size was a very small 0.14. Among those for whom the experience had a larger SDLRS impact (10+ points), 37 percent gained while about half that number (20 percent) declined in their scores. A scatter plot (Figure 5) of SDLRS change against initial SDL readiness reveals that those most likely to benefit from the experience in terms of SDL readiness were those with lower initial scores.

Looking at sub-populations within the cohort, average scores by gender were quite similar (males 219/222 pre/post, females 221/223), though males improved somewhat more on average (3.7 points, $p = 0.03$) than did females (2.5 points, $p = 0.48$, not statistically significant). The distribution of male and female students with respect to the $+/-$ 10 point threshold was quite similar. Students completed their projects in one of eleven WPI Project Centers, of which five were located in places where English is a primary language (London, Australia, Puerto Rico, Boston, and Washington) and six were in primarily non-English speaking locations
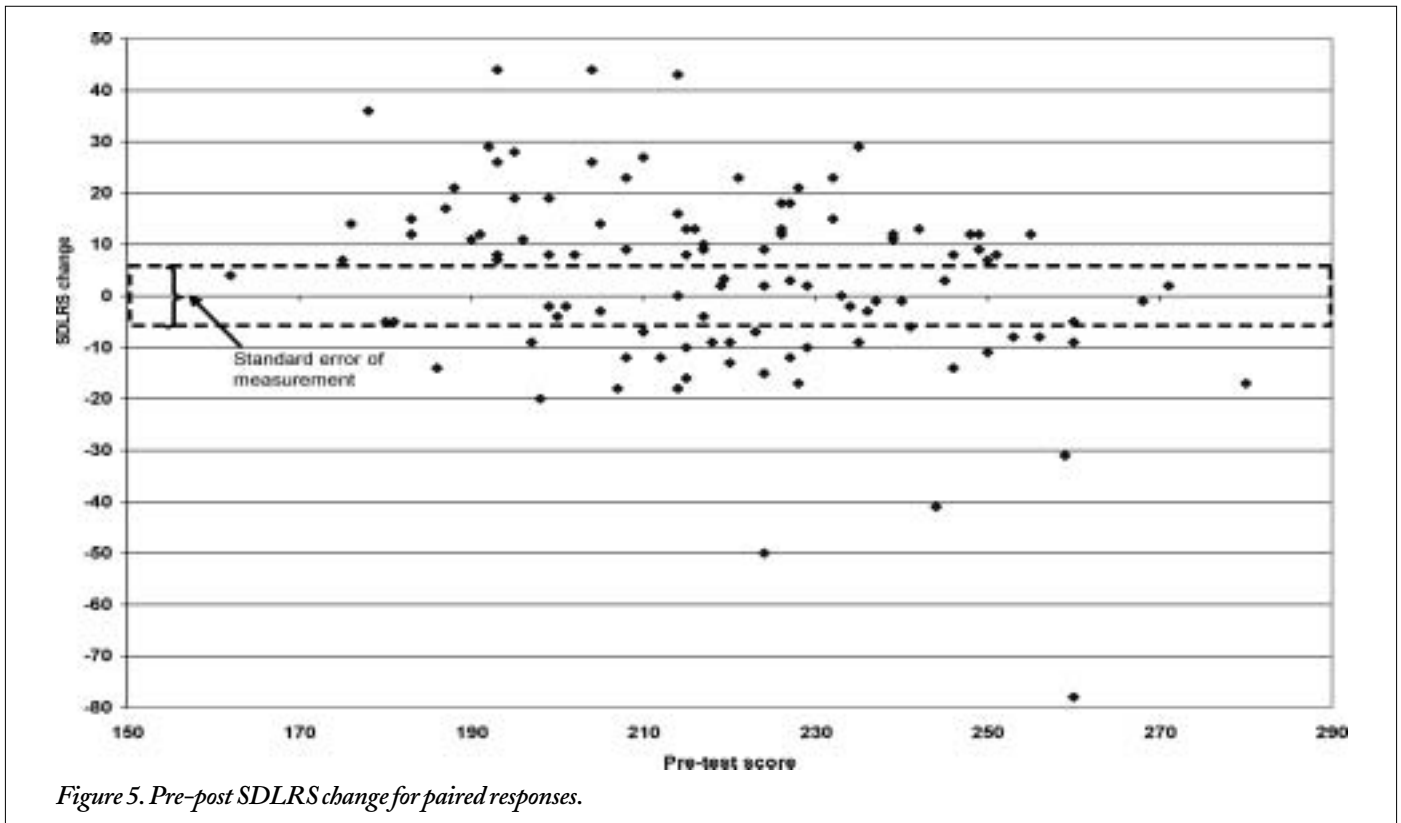
Figure 5. Pre–post SDLRS change for paired responses.

(Bangkok, Copenhagen, Costa Rica, Venice, Zurich and Namibia). Students sojourning to English-speaking Project Centers started with significantly lower average SDLRS scores (216 versus 224), but gained more (4.6 versus 1.4) than their non-English Project Center counterparts.

These results are similar to those obtained by Litzinger and colleagues [1–3]. However, the Penn State study [3] did show a statistically significant increase in SDLRS, on average, for a problem-based learning experience. The means shown here are somewhat lower than those reported by Penn State seniors in capstone design but are comparable to juniors at Penn State [1]. All the students in the WPI cohort were fifth or sixth semester juniors. Our results indicate that WPI's nontraditional, experiential off-campus project experience has a positive impact on student SDL readiness. On average, and for many individuals, the depth of these gains appear modest, although for a sizable group the gains are impressive and hence potentially an indicator of real educational accomplishment in promoting LLL. More worrisome, however, are the corresponding SDLRS declines reported by a smaller fraction of students.

V. DISCUSSION AND CONCLUSIONS

We investigated student progress on educational outcomes related to LLL that most colleges agree are essential for their graduates. The success of traditional and nontraditional curricula in delivering these outcomes, however, is only indirectly measurable because they relate fundamentally to future behavior, the life-long and self-directed learning activities of students. Thus, as we noted earlier, research about how to meet and measure these important educational goals remains incomplete, and there continues to be a need for critical testing of both educational approaches and outcomes assessment.

Overall, our results point toward a successful educational model for promoting LLL. Much more than others, students in the preparation phase of WPI's off-campus project experience see themselves having made significant progress in their writing, critical thinking and research skills. Further, tangible evidence at the end of the project, in the form of final reports assessed independently by faculty teams, shows study-abroad students clearly demonstrating these abilities at higher levels than those who conduct their projects on campus. Finally, results from the SDLRS research instrument designed to measure SDL readiness most comprehensively and directly also show students benefiting from the program, but less dramatically and with greater variability than indicated through the other assessment methods.

These results have implications both for the design and delivery of nontraditional educational programs aimed at promoting LLL, and for the assessment of these programs. We reflect first on the assessment issues, exploring differences among and lessons learned from each of the methods employed here, and then conclude with educational programming suggestions.

The key methodological question is, "Why are student and faculty assessments of strong and broad-based progress on specific core SDL/LLL capacities not more closely mirrored in the comprehensive assessment of SDL readiness?" We speculate the answer may involve the different ways in which complex SDL/LLL phenomena are operationalized in each method, and the potentially variable timeframes through which students are likely to incorporate and express these phenomena (Table 6). The IDEA assessment, for example, measures student self-reports of progress on LLL-related learning objectives after just the preparation phase of project development, prior to leaving campus. We know both anecdotally and through many years of course evaluations that students find this preparation course amongst the most demanding of their college

Instrument, Results	Observer	Observations of…	Time Frame
1. IDEA, Strong Positive	Self	Self-perceptions of SDL abilities	Short
2. Report Analysis, Strong Positive	Faculty	Written evidence of SDL	Short
3. SDLRS, Modest Positive	Self	Self-perceptions of SDL attitudes and abilities	Short → Long

Table 6. Comparison of SDL indicators.

careers. Expectations for writing, presenting, critical thinking, and open-ended research are high, and students report working much harder, and often enjoying it less, than other courses. For our mostly technically-oriented students, this is a much different educational experience, especially as it relates to the social and qualitative dimensions of the work. The preparation is also a significant rite of passage: they must pass the course in order to continue with the project, and more importantly, they must perform at a high level to meet the expectations of project sponsors, advisors, teammates and WPI's educational standards. It is reasonable to expect that students will therefore see significant short-term progress on these SDL-related skills and abilities, both in reality and in their self-perceptions, as reported through the IDEA system.

Similarly, it is not surprising that generally the greater institutional support and intensity of the student experience in the Global Program relative to the on-campus project experience will result in final project reports assessed by independent faculty as demonstrating, on average, higher levels of LLL-related achievement. As noted above, this higher overall performance of study abroad cohorts is only slightly related to GPA. Better performance of Global Program participants is related to the structure and nature of the off-campus experience. It is important to note that most on-campus project students also find that experience very challenging, and many demonstrate similarly high levels of accomplishment and LLL development, though less consistently than Global Program students. Given the significance of the project report as the culmination of this intensive educational experience, and its weight in determining the equivalent of three course grades and possibilities for graduating with honors, it is again not surprising that independent faculty observers would often detect strong evidence of students demonstrating SDL capacities, at least over the short-term of the project experience.

These strong and broad gains in LLL capacities are only modestly reflected in the SDLRS test and may mean the WPI program is only marginally successful in accomplishing these objectives. Despite the intense experience, perhaps the time away from campus (two months) is not sufficient to expect larger improvements. Alternatively, it may be that the kind of fundamental, attitudinal, and behavioral characteristics the SDLRS is designed to assess develop at a more tectonic pace than that of the project period, especially when the post-test, for logistical reasons, occurs amid the final hectic days of project completion when introspective reflection is difficult to expect. This may be especially true given the many questions on the SDLRS (over one-third, by our count) asking in one form or another about the student's enthusiasm for learning: *Learning is fun,*

I'll be glad when I am finished learning, I love to learn. Learning may not seem particularly fun while pressing to finish a project and major report.

It is also possible that lasting personal growth and development, and self-awareness of same, requires a period of assimilation with opportunities for students over time to apply new, or newly strengthened, SDL capacities in later life experiences. With phenomenon as complex as SDL/LLL, the answer is likely somewhere in the messy middle: many alumni look back on their project experience and tell us it was a formative and beneficial initiation in dealing with open-ended learning challenges of a sort encountered throughout their later careers. For others, the short-term plunge into an environment demanding strong development of SDL capacities may have little lasting effect on LLL propensity, and others may even have been persuaded to actively avoid such open-ended challenges in the future.

To better understand the relationship between the acquisition and short-term expression of relatively concrete and demonstrable SDL capacities and the more amorphous incorporation of independent learning qualities into a student's self-identity, tastes, and anticipated behaviors, we believe complementary methods to those used here are needed, especially methods other than surveys of student self-perceptions and attitudes. Qualitative methodologies such as interviews, observation, or ethnography would be particularly useful. They allow for a deeper and more detailed understanding of student learning (and preparation for self learning) that is constructed by interpreting observed behaviors and responses rather than relying on self-reports. Although such work was beyond the scope of the current study, our results do help provide a base for future research design.

Without such additional research, we hesitate to make sweeping curriculum recommendations. The research does raise some educational issues worth mentioning, however. Most basically, the experiential program reported here demonstrates clear success in promoting SDL readiness and is promising with respect to LLL, and offers a potential model for others interested in achieving these outcomes. Key variables of program success likely include building the experience around real, open-ended projects; conducting the projects in centers away from campus (often abroad); providing a full-time, dedicated project period for an immersion experience; and establishing high levels of expectation and support for students. The relative importance of these factors is unknown and warrants further research.

One caution that emerges from the research is that attention needs to be paid to the potentially negative SDL impacts such

programs may have on some students. We know that most students go through personal and professional changes even during two-month sojourns, and other study abroad research has shown that students can exhibit negative changes in self-confidence and self-efficacy affecting their world view and confidence in their career path [15]. We have observed this, anecdotally, in some WPI students. How this impacts SDLRS scores and how this might change over time (post-sojourn), is not known. This research suggests, however, perhaps surprisingly, that students with initially high levels of self-perceived SDL readiness may be disproportionately at risk for having negative SDL experiences. Also, those sojourning to non-English speaking locations may also be at greater risk. This is partly validated by Candy [6] in his discussion of the context dependency of SDL. Learners show different changes in SDL abilities depending on the learning context.

Thus, while the research and experience indicates the program generally achieves positive LLL outcomes, with students able to address and solve fairly complex, open-ended, multidisciplinary problems characteristic of post-graduate professional life, it also highlights the need to better understand and assist students for whom the experience may not be positive. Additional, richer research methods may be necessary to accomplish these ends, and to more fully understand relationships between educational programs and student preparation for life-long learning.

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