

# **Perceived Self-Efficacy, Learning Habits and Peer Learning Forums in an Online Asynchronous Programming Offering**

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## **Overview**

This study broadens the objectives of previous work (Boyer, Langevin, Gaspar, 2008) in which we used the PRO-SDLS “Learning Experience Scale” instrument (Stockdale & Brockett, 2006) as a new perspective from which to measure the impact of innovative approaches in the teaching of computer programming in online courses. We investigate how our students’ self-efficacy profiles (Pajares, 2002), as measured by the PRO-SDLS instrument, relate or differ from observable self-efficacy (OSE) indicators. For our study, these indicators have been provided by attitude surveys inquiring about the learning habits of our students (e.g., time devoted to coursework, nature of the learning activities the students are engaged in, etc.) as well as their participation in weekly Peer Learning Forums (PLF) learning activities (e.g., time between first post in the week and deadline, indications of self-efficacy or lack thereof in the formulation of questions and their contents).

## **Introduction**

This study is based on the offering of an undergraduate online asynchronous programming course during fall 2008 at the University of South Florida Polytechnic Information Technology department (USFP IT). "IT Program Design" is an intermediate computer programming course using the c programming language. The remainder of this introduction describes the various pedagogical approaches which were leveraged in this course along with the student population which was enrolled in it. We then discuss the research questions this study will address.

### **Pedagogies used in "IT Program Design"**

The "IT Program Design" course is a programming course intended for students who have already been exposed to at least an introductory programming course (typically taught in Java or c++ at a community college level). It re-explores the fundamentals of programming by using a lower level language, c, in order to not only strengthen students' programming rigor but also prepare them for upper level, system-oriented courses in the IT curriculum. This offering relies on weekly learning activities which leverage peer learning dynamics through Blackboard's forums. Every Monday, students are assigned one or more chapters to read from their textbook. An online module is made available which specifies the reading assignment and provides so-called "apprenticeship exercises" which offer students the opportunity to apply the material to hands-on problems. These exercises are accompanied by video solutions which show them how to develop the programs from scratch rather than imparting a finalized solution. We found in a previous study that this approach was a suitable adaptation of the idea of cognitive apprenticeship to programming courses (Boyer, Langevin, Gaspar, 2008). By Thursday, students are expected to have posted one or more questions on a weekly Peer Learning Forum (PLF) devoted to the module being studied. These questions are meant to help students overcome learning barriers they encountered during their readings or while working on the apprenticeship exercises. The deadline is meant to give enough time for other students to see all the questions before the week is over. Students who indicated they had no questions about the weekly material were encouraged to post "challenge questions" for their peers on what they deemed to be the most difficult aspect of the material. This allowed them to get credit when working on modules with which they didn't have issues. From Thursday to Sunday, students were expected to revisit the PLF's posts and attempt to answer their peers' questions. It was expected that this would be easy for students who already grasped the material but would most likely lead others to realize they might have missed parts of the material and revisit their reading assignments, guided by their peers' questions. Each PLF is graded, granting students 2 points for timely and meaningful posts (both questions and responses are expected). Over the 16 week semester, nine PLF's are used, each associated with a single module. Three more non-graded PLF's are used for review prior to each of the exams. The following Monday, the instructor "wraps up" every thread in the previous week's PLF and provides answers to students, confirming the responses which were on target and correcting those which weren't. New mini-lecture videos are released, when appropriate, to convey answers to particularly difficult questions which tend to recur each semester. In addition, a graded quiz is released for students to take within a week in order to test their conceptual and factual understanding of the contents of the previous module. Finally, the following module's

reading assignments, apprenticeship exercises and PLF are released and a new weekly learning routine starts.

### Sample population

Our population consisted of students enrolled in an Information Technology (IT) program; our sample was 14 students enrolled in the online asynchronous IT Program Design course during fall 2008. This sample was comprised of 6 males and 8 females. Table 1 summarizes our sample's characteristics in terms of age (4 students were in the 18-20 range, 0 over 50 years old), course load (i.e. number of 3 credits courses taken during the semester) and work load (there were no non-working students, with an even distribution between those employed part and full time).

Most of these students have transitioned from a community college into the university following the 2+2 model established within the State of Florida. Others may be more mature adults returning for further education beyond technician level credentials. Most students are therefore non-traditional with regard to age and employment. These characteristics make it extremely interesting to investigate how pedagogical interventions, which have been the focus of the computing education community, fare with students who have generally little time (or motivation) for in-depth learning and might be motivated to get a "drive through" education as a way to facilitate professional advancement.

Age group	18-20 (4), 21-30 (6), 31-40 (3), 41-50 (1), 50+ (0)
Course load	1 (2), 2 (1), 3 (1), 4 (8), 5 (2)
Work load	None (0), Part time (7), Full time (7)

Table 1 – Sample Population General Information (N=14)

### Focus of this Study

This study was motivated by an observation made in a previous offering of "IT Program Design" during summer 2008. As part of course improvement, we administered the PRO-SDLS instrument, using an online survey tool (surveymonkey.com), to our students. The instrument was used during the first week of class (mandatory participation to survey with possibility to opt out, used to confirm first-day attendance) and during the last week of class (optional participation with extra credit available). The results, not yet published, indicated that the five students who participated in both pre and post surveys exhibited a lower self-direction score at the *end* of the semester. This prompted us to explore further whether the measures obtained with the PRO-SDLS instrument during the pre-survey were appropriate reflections of the students' self-direction in this particular context. We identified the following research directions to further explore this:

- The PRO-SDLS is meant to measure self-direction in a rather general manner, regardless of the subject matter. It is conceivable that students who are generally self-directed might find themselves uncomfortable with programming activities. The fact that "IT Program Design" is an early course in the USFP IT curriculum makes it more likely to find, among enrolled students, individuals who will later opt out of the discipline after realizing it was not what they expected.

- It is also conceivable that the responses of our students in the PRO-SDLS survey reflect a perception they have of themselves which has not yet been confronted with the requirements of an asynchronous programming online course.

We therefore decided to investigate the differences between our students' self efficacy as *expressed* through their self-perceptions (PRO-SDLS) but also as *observed* by the instructor and with respect to the programming material being taught. We decided to focus this first study on the self-efficacy factor of only the PRO-SDLS instrument for two reasons. First, we estimated that a student's self-efficacy (or lack thereof) with respect to programming (on-computer activities) or the way they engage with the material (exercises, reading assignments) is something which can be observed by analyzing the questions posted on the weekly peer learning forums. Second, our team's preliminary experience with the PRO-SDLS instrument indicated that self-efficacy was one of the most reliable factors. We will confirm this in the data analysis section of this paper where we will detail the Cronbach Alphas coefficients for our data set. Based on this, we identified the following research questions:

- How can students' self-efficacy levels be assessed based on the questions they post to a mandatory, weekly Peer Learning Forum?
- How does their self-efficacy, as measured by the PRO-SDLS instrument, relate to how self-efficacy is expressed through their participation in Peer Learning Forums?
- How does students' self-efficacy, as measured by the PRO-SDLS instrument, relate to their self-perception of their learning habits as expressed in an attitude survey?

## Methods

This section details the instruments we used to measure both the self-perceived self-efficacy (SPSE) and the observed self-efficacy (OSE).

### **Measuring SPSE – Self-Perceived Self-Efficacy with PRO-SDLS**

In order to measure students' self-perceived self-efficacy, we relied on the PRO-SDLS instrument which was administered during the first week and last week of the course. We retained the data for students who took both pre and post instruments (N=5) and for those who only took the pre-survey (N=14). Survey results were not accessible directly to the instructor but were received and processed by a team member not involved in the teaching of this course and who provided the instructor with a simple list of students who took the survey. Students could also exercise an option to take the pre-survey for attendance purposes but to opt out of actually answering survey questions.

We removed the data provided by students who responded to the PRO-SDLS instrument by checking uniformly the highest responses of the Likert-scale, thus contradicting themselves on PRO-SDLS' inverted rating questions. These outliers were also removed from every other instrument's data sets since we aimed at establishing correlations between the various perspectives on students' self-efficacy as well as the differences between pre and post measures.

## Measuring OSE / PLF – Observed Self-Efficacy in Peer Learning Forums

In order for us to observe students' self-efficacy with respect to programming and as expressed through the students' posts in the weekly Peer Learning Forums' learning activities, we devised a simple way to classify students' questions into three categories. Table 2 details several types of questions which occur regularly on these peer learning forums. For each, we described indicators that would allow discrimination between positive (OSE / PLF +) and negative (OSE / PLF -) observed self-efficacy. These indicators are accompanied by examples of archetypal questions belonging to this category.

Type of question	OSE / PLF+ Positive OSE indicator	OSE / PLF - Negative OSE indicator
The student uses the peer learning forum to verify a hypothesis they have.	<p>The hypothesis indicates that the student has developed an understanding (<i>correct or not</i>) of the situation – an understanding of what they are having problems with.</p> <p>The student points out perceived contradictions in the text or attempts to consolidate divergent perspectives presented within text or in various external sources.</p> <p><i>e.g., "Section 3.9 states that x is always &gt; y which I understand is because of the alignment problem, but then the program in figure 3 doesn't check for that explicitly. Does this mean the constraint is not implemented?"</i></p>	<p>The hypothesis doesn't indicate that the student has developed an understanding (<i>correct or not</i>) of the situation. This encompasses direct requests for re-explanation of portions of the material without specifics.</p> <p><i>e.g. "I don't understand section 3.9", "can I get more examples of sorting algorithms?"</i></p>
Student is asking help understanding a concept.	<p>The concept is not covered in the material and the student's question indicates that they tried to gather information about it first.</p> <p><i>e.g., "I'm assuming that sizeof measures the size of a variable by looking up its memory location?"</i></p> <p>The student's question indicates that they are trying to understand how to apply specific knowledge beyond the scope of this class.</p> <p><i>e.g., "The text refers to the pow() function and others but where do you find information on which functions are available for your programs?"</i></p>	<p>The concept is already covered in the material; the student's question doesn't indicate they tried to gather information about it first.</p> <p><i>e.g. "I can use the sizeof operator in my programs but I'm not sure how it works?"</i></p>

<p>The student asks for help while experimenting with existing programs (e.g., examples from the text, solved exercises, ...)</p>	<p>The student requests help to understand the reasons behind the results of experimenting with a program (trying alternative syntax, modifying an example or solved exercise, testing a specific construct). While the reasons for the outcomes are not clear, the student provides evidence of having actually experimented hands-on with the program.</p> <p><i>e.g., "I used a %21.2f in my printf with various numbers (see list below) and it seems the 21 doesn't care about the number of decimals. This is not what is explained in section 9.3 though!"</i></p>	<p>The student requests that others tell him what would happen when running a certain program, using a syntactical construct in a certain way, or modifying an example in a certain way. The outcome could be simply observed by actually typing the program and experimenting with it.</p> <p><i>e.g., "What would happen if I used Printf instead of printf in one of my programs?"</i></p>
<p>The student uses the peer learning forum to ask a question about a programming problem.</p>	<p>The student has developed for themselves a program to solve the given assignment.</p> <p>The student provides detailed information about the erroneous behavior exhibited by their program.</p> <p>The student provides information about hypothetical reasons for their program's erroneous behavior.</p> <p><i>e.g., "My program is always off by one in the Fibonacci series and I've tried starting my loop at 0 or 1 but it seems it's the conditional that is not appropriate; any help?"</i></p>	<p>Student asks for a solution to a given programming assignment without providing evidence of having worked on a solution of their own; e.g., a specific problem they encountered making their solution work.</p> <p>The student provides a program and requests that others find out what is wrong with it.</p> <p><i>e.g., "Why is the program below not working?"</i></p> <p><i>e.g., "I don't understand how to start program 9.9"</i></p>

Table 2 – Indicators of Observed Self-Efficacy (OSE) in Peer Learning Forums w/r to programming

In addition to this classification of posts, we also used three measures to inform our study on the nature of students' participation in the weekly PLF learning activities (see Table 6);

- The overall number of questions posted by students which are rewarded by participation incentives (RQ). "IT Program Design" used nine PLF's over the semester. Students were expected to post a minimum of one question per PLF. Only one student posted more than 9 questions over the course of the semester (minimum to get full participation credit). This minimal or insufficient participation of students might be interpreted as a negative indicator of self-efficacy insofar as it is an observation of their willingness to engage only in learning activities to the extent to which those activities are made mandatory and rewarded appropriately.
- The overall number of questions posted by students after the deadline (EQ). These have to be considered as "extra questions" which are not motivated by the participation incentive and are therefore to be viewed as a request for help from the students along with an engagement with the PLF learning activities.
- Time to deadline (TTD). The TTD column in Table 6 represents a measure of how early in the week students start working on their PLF assignments. It has been coded as the number of

minutes between the first question post for a student and the weekly deadline to get questions posted for credit. A high value therefore indicates an early start. The number in the TTD column of Table 6 is the average for the nine PLF learning activities in “IT Program Design,” rounded up to the nearest integer.

### **Measuring OSE / LH – Observed Self-Efficacy in Learning Habits**

In order to observe students’ self-efficacy from yet another perspective, we administered an attitude survey which asked students to describe their learning habits. This survey was administered using an online tool (surveymonkey.com) during both the first week and the last week of each course.

The relevant questions in the survey were as follows:

Q1 – How many hours do you typically spend on a 3 credit hour course?

Q2 – What kind of learning activities do you usually engage in while working on a course at home (check as many as apply)?

- Reading the textbook’s assigned chapters
- Reading the textbook’s unassigned or extra material (\*)
- Doing assigned exercises (graded ones)
- Doing assigned exercises (non-graded ones) (\*)
- Doing unassigned exercises (picked yourself) (\*)
- Re-doing exercises for which you already have the solution (\*)
- Reading the solutions to such exercises without redoing them
- Searching online for extra material (explanations) (\*)
- Searching online for extra material (exercises to do) (\*)
- Searching online for extra material (code samples) (\*)
- Others

No student provided responses in the “Others” category for Q2. The responses marked with an asterisk in Q2 (\*) are the ones which we used as positive indicators of observed self-efficacy with respect to learning habits (OSE / LH+). Outliers were handled by removing from the data set those students who provided non-sensible responses to the demographic questions of the survey related to their academic workloads (e.g., a student who reported taking 160 credit hours of coursework this semester).

Two types of measures were used to provide indications of self-efficacy with respect to the students’ learning habits:

- The number of hours (NH) which students indicated spending on a typical 3 credit course (NH-pre for the pre-survey) and the number of hours they indicated having spent on our course (NH-post for the post-survey).
- A score indicating how students responded to the survey questions meant to identify self-efficient learning habits (OSE / LH+). A point was attributed whenever students checked one of these answers (identified in the above list with an asterisk). This resulted in a score ranging from 0 to 7.

## Data Analysis

This section details the results obtained after applying the above-mentioned instruments to our sample population. We discuss separate data sets before we take a closer look at the correlations between measures.

### SPSE Analysis – Self-Perceived Self-Efficacy with PRO-SDLS

A total of fourteen students took the PRO-SDLS instrument and responded to the pre-survey; five of those students responded to *both* the pre- and post-survey. The mean of the total score (with standard deviations in parentheses) for the **pre** PRO-SDLS administration was 90.64 (12.30). The mean of the **post** administration of the PRO-SDLS was 82.20 (3.77). A complete list of the descriptive statistics can be found in Table 3, including minimum and maximum values.

	Mean	St. Deviation	Minimum	Maximum
Pre- Total Sum Score (n=14)	90.64	12.30	75.00	109
Pre- Question Statistics	3.63	.53	2.50	4.36
Post-Total Sum Score (n=5)	82.20	3.77	78.00	88.00
Post-Question Statistics	3.36	.74	1.60	4.40

*Table 3 – Descriptive Statistics for PRO-SDLS scores (N=14)*

The questions from the instrument and corresponding descriptive statistics, by question, can be found in Appendix A. The pre-mean (4.29) and post-mean (4.00) on question 1 suggests that the majority of students are convinced that they are confident of their ability to consistently motivate themselves. In addition, most students indicate that they see a connection between the work for their courses and their personal goals and interests (pre-mean 4.21, post- mean 4.40) while also perceiving that they can make the necessary changes to improve their learning (pre-mean 4.14, post-mean 4.00). Finally, most students believe they can take primary responsibility for their learning (pre-mean 4.07, post-mean 4.40). Providing an interesting contrast, students do not appear to collect additional information about interesting topics after the course has ended (pre-mean 2.93, post-mean 1.60).

Learner Characteristics Component							
Self-Efficacy Questions	1	7	12	21	22	24	Total
Pre-Administration	4.29	4.21	4.14	4.07	3.79	4.14	24.64
Post-Administration	4.00	2.40	3.60	4.20	4.40	3.80	22.40

*Table 4 – Question Means: Pre-Post for the Self-Efficacy Factor (N=14 for pre and N=5 for post)*

The PRO-SDLS data appeared to be reliable on both the total instrument (.89) and the instrument factors, with some being stronger than others. The self-efficacy factor was reliable (.82), as was the motivation factor (.83) and the control factor (.80). Overall, these strong alpha values suggest confidence that the questions are adequately capturing the concepts that we hope to measure.

### **OSE / PLF Analysis – Observed Self-Efficacy in Peer Learning Forums**

We used table 2 to categorize the students' PLF posts during fall 2008 in the "IT Program Design" course. Two of the authors independently used the table to classify the questions and then compared their results to gain insights about the reliability of our classifier instrument. Results of our classifications are provided in Table 5 below. Each observer reviewed each question post for each student and, according to our classifier instrument, categorized them as indicating positive or negative observed self-efficacy (OSE/PLF+ or OSE/PLF-). In addition, posts which were not relevant for this classification were instead assigned to an "n/a" category. After this initial sorting, the percentage of posts from each student in each category, relative to their total number of posts, was computed. Therefore, each student ended up with three percentages representing the distribution of their posts in the OSE/PLF+, OSE/PLF- and n/a categories. The two authors made an independent analysis and then compared their classifications and revisited each decision in order to adjust the instrument. The result is presented in Table 5 below.

Distribution of posts	OSE/PLF+	OSE/PLF-	n/a
average	32.72%	58.89%	8.39%
std dev	0.31	0.31	0.19
min	0.00%	0.00%	0.00%
max	100.00%	100.00%	66.67%

*Table 5 – OSE / PLF measures (N=14)*

In addition to this classification, Table 6 summarizes the results of the various measures detailed in the "Methods" section:

- The students' Rewarded Questions (RQ – questions posts made by the weekly deadline and rewarded by participation incentive)
- Extra questions (EQ – questions posted after the weekly deadline and not rewarded by participation incentive)
- Time to Deadline (TTD – average number of minutes separating the student's first weekly question to the deadline to receive credit for it as participation in the weekly PLF).

statistics	RQ	EQ	TTD
average	5.36	0.21	276.20
std dev	4.38	0.43	292.61
min	1.00	0.00	13.00
max	18.00	1.00	865.89

*Table 6 – Number of rewarded questions (RQ), extra questions (EQ) and average Time To Deadline for posts (N=14)*

Table 6 indicates clearly that students didn't post many questions past the Thursday 11:55pm weekly deadline after which they would not receive credit for PLF participation; the EQ measure represents 2 questions posted by 2 different students over the entire semester. This is also consistent with an almost total absence of posts during the "review weeks"; before each of the 3 exam weeks, students had review assignments and were invited to participate in a non-graded peer learning forum. These three review PLF's saw no significant participation over the semester. These observations can be interpreted as a lack of self-efficacy insofar as they indicate a lack of engagement with the learning activities beyond what is directly rewarded by participation points. This might also be a reflection of one of the main distinguishing characteristics of our student population at USFP: overcommitted adult learners who have extremely limited resources to devote to their education and, sometimes, perceive class work as getting in the way of their personal/social objectives, i.e., getting the degree to ascend to a better salary bracket.

### **OSE/PLF Analysis – SPSE vs. OSE/PLF**

The observations we made about the analysis of OSE/PLF indicators are somewhat disconnected from students' self-perception of their self-efficacy (as expressed through the PRO-SDSLS section of the pre-survey).

The correlation between the number of overall questions posted (RQ) and the PRO-SDLS self-efficacy factor indicates that the two are not significantly correlated (.085). Similarly, the correlation between RQ and the overall PRO-SDLS score is small (.228). The number of questions posted by students is therefore not a valid indicator of their self-efficacy in this population. This is consistent with the observation that students strongly tend to "do the minimum" and adopt a compliance attitude toward assignments (as made evident by the almost total lack of non-rewarded posts in Table 6). This attitude

leads the RQ measurement to be driven primarily by the syllabus rather than students' engagement with the learning process.

The Time to deadline (TTD) measure has a higher correlation with the PRO-SDLS self-efficacy factor (.362) and overall scores (.396). This medium correlation indicates that the students who perceived themselves as self-directed or as having a high self-efficacy tend to start working earlier in the week on their assignments. This tendency to "spread" the workload ahead of deadlines allow students more time to reflect on the material and might be a sign of a better capability to organize one's work.

The correlation between these two measures (RQ and TTD) is only medium (.343) which provides another validation of the observation that RQ is irrelevant in any judgment about self-efficacy but might link together students who are posting few questions and those who are participating in the forums at the last minute. The correlation being only .343, we can only assume that this is not the rule in our population which, once again, makes sense given the specifics of our student population (most of the PLF participation is compliant in nature).

	PRO-SDLS		PLF				LH	
	SE factor	overall	RQ	TTD	OSE/PLF+	OSE/PLF-	OSE/LH+	NH-PRE
SE factor		0.922	0.085	0.362	-0.552	0.566	-0.111	0.049
overall	<b>0.922</b>		0.228	0.396	-0.584	0.535	0.011	0.178
RQ	0.085	<b>0.228</b>		0.343	0.026	-0.010	0.021	0.353
TTD	0.362	<b>0.396</b>	<b>0.343</b>		0.204	-0.083	0.337	0.479
OSE/PLF+	<b>-0.552</b>	<b>-0.584</b>	0.026	0.204		-0.820	0.079	0.527
OSE/PLF-	<b>0.566</b>	<b>0.535</b>	-0.010	-0.083	<b>-0.820</b>		0.053	0.264
OSE/LH+	-0.111	0.011	0.021	<b>0.337</b>	0.079	0.053		0.595
NH-PRE	0.049	0.178	0.353	0.479	<b>0.527</b>	0.264	<b>0.595</b>	

Table 7 – Inter-instrument correlations (N=14)

Now that we have looked at how both the RQ and TTD measures of students' PLF participation relate to the SPSE measures provided by the PRO-SDLS instrument, let's take a look at how the instrument we developed to measure OSE/PLF (see Table 2) relates to SPSE.

The correlation between OSE/PLF+ and OSE/PLF- is -.820. This "verification" measure confirms that the instrument successfully captures inverse trends in students' posts. We then correlated our OSE/PLF+ measure to both the PRO-SDLS global score (-.584) and self-efficacy factor only (-.552). Both of these indicate relatively strong negative correlations. Symmetrically, the correlations of our OSE/PLF- measures to the same PRO-SDLS measures are relatively strong positive ones (respectively .566 and .535). This observation is most interesting insofar as it indicates that the measures of self-efficacy as observed by the instructor through the students' participation in PLF learning activities are contradicting the students' self-perception of their own self-efficacy. At a first level, this might indicate that our instrument captures a different aspect of our population's self-efficacy. This aspect would be discipline-dependent insofar as our instrument (see Table 2) focuses on classifying students' posts based on what would be a self-efficient learning approach for programming. It is interesting to note that the activity of

programming itself can be seen as divided in various sub-activities such as (1) designing the solution, (2) implementing it in a given programming language and (3) troubleshooting design or implementation. The rows in table 2 reflect the fact that, as we analyzed the posts, we encountered examples which indicated that some students might be self-efficient with respect to designing solutions (e.g., asking questions about various alternative algorithms) but very little engaged with hands-on testing of their hypotheses. On the other hand, other students have contributed very hands-on oriented posts (e.g. testing a hypothesis with the help of a small program and sharing their results to gain help) while not really questioning concepts of algorithms presented in the reading assignments. It would be unrealistic to expect a general instrument such as the PRO-SDLS to capture discipline-specific self-efficacy behaviors and even less to expect it to capture subtle nuances within a given field (e.g. design vs. implementation vs. troubleshooting). Therefore, while students might have a high self-efficacy as a general attitude toward learning, they might find themselves relatively compliant only when dealing with a programming course. This could partially explain the lack of direct correlation between the two measures.

Another possibility to keep in mind is that the USFP IT department has switched to online asynchronous courses relatively recently. This means that, for early courses in the curriculum, students might be taking a course offered in such a delivery format for the first time. As such, their self-perception of self-efficacy might be based on more traditional, face-to-face, offerings in which the demand wasn't as high on their capability to engage independently with the material and/or spend most of the class activities reflecting on it with peers and instructors instead of listening to a "sage on the stage". This raises an interesting question about the validity of students' answers to an instrument such as the PRO-SDLS when they have been exposed to pedagogies which didn't allow them to confront their view of their own self-efficacy with a realistic challenge.

We looked at the differences between the PRO-SDLS global scores and self-efficacy factors only as expressed by students during the pre-survey (first week) and the post-survey (last week). The results are summarized in Table 8. Only 5 students from the "IT Program Design" course took both the pre and post surveys, thus reducing our sample size to about a third of the total number of students who took the pre-survey and reducing accordingly the depth of what we can conclude from these observations. It is nonetheless interesting to note that the average, for these 5 students, of the difference between their pre-survey and post-survey scores indicates that both global and self-efficacy only scores *decreased* over the semester. In conjunction with the above observations, this indicates that the students who took the post survey voluntarily, and didn't drop the class earlier, have revised their self-perception of their self-efficacy over the course of the semester. This observation would tend to add weight to the hypothesis that our lack of correlation between the OSE/PLF measures and PRO-SDLS ones is based, for a significant part at least, on a misconception of what self-efficacy might be with respect to programming on the part of our students or a misconception of their own learning behaviors and habits. We will explore further these learning habits in the upcoming sections to complement this first analysis.

students IDs	SE only			global SD measure		
	pre	post	deltas	pre	post	deltas

average	24.6	19.4	-5.2	91.6	82.2	-9.4
std-dev	4.67	1.34	5.07	13.35	3.77	15.92
min	18	18	-12	75	78	-27
max	30	21	2	107	88	13

Table 8 – Differences between pre and post PRO-SDLS scores and Self-efficacy factors (N=5)

### OSE / LH Analysis – Observed Self-Efficacy in Learning Habits

Let us now take a look at student responses to the attitude survey on learning habits. Table 9 summarizes, for each student, the number of times they selected responses which we identified in the previous section as positive indicators of observed self-efficacy in the learning habits attitude survey. The maximal score for this OSE / LH+ indicator is 7. There is no negative OSE/LH indicator insofar as the responses which we estimated as being indicators of negative observed self-efficacy would be interpreted as compliance to course requirements by most and would therefore not lead to identifying behaviors which are strictly anti-self-efficacy. The number of hours which students declared spending on a typical 3 credit hour course is also indicated in this table. These two measures are available from both pre- and post-surveys.

	OSE/LH+	NH-PRE
average	2.928571	4.2
std dev	2.02	2.62
min	1	1
max	7	9

Table 9 – Summary of Learning Habits attitude PRE-survey for “IT Program Design” (N=14)

We compiled the same information from the post-survey and measured differences between pre and post surveys for the 5 students who took both, as shown in Table 10.

statistics	OSE / LH +			NH-PRE and NH-POST		
	pre	post	deltas	pre	post	deltas
average	4.2	2.4	-1.8	6.2	4	-2.2
std dev	2.59	0.55	3.03	2.17	2.55	4.15
min	2	2	-5	4	1	-7
max	7	3	1	9	7	3

Table 10 – PRE / POST differences for OSE/LH+ and number of hours (NH-pre, NH-post) (N=5)

The difference (post value - pre value) in the number of hours indicate that the 5 students who took both pre- and post- versions of the survey decreased their weekly time commitment to the course well below the expected university standards of 12 weekly hours (about 3 hours work per credit hour in addition to the weekly 3 hours lectures). The difference observed for the OSE/LH+ measure would indicate a negative impact on students as well.

These results are difficult to interpret due to the size of the sample as well as the absence of any performance indicator to put the learning habits' evolution in perspective with student performance. This motivates us to focus in future studies on the link between the various self-efficacy indicators and students' performance in terms of grades or pass/fail.

## **OSE/LH Analysis – SPSE vs. OSE/LH**

We then ran correlations to evaluate how the measures related to learning habits (OSE/LH+ and the # of hours) correlated to the SPSE measures in the PRO-SDLS pre-survey. Results are summarized in Table 7.

The NH-PRE measure has a non-significant correlation with the self-efficacy PRO-SDLS factor (.049) and a small one with the overall PRO-SDLS score (.178). However, it is interesting to note that this same measure has a large correlation with the OSE/PLF+ (.527) instrument and a small one with the OSE/PLF- instrument (.264). This indicates that, although NH-PRE doesn't seem to relate to how students perceive their self-efficacy, it correlates with their observed self-efficacy when engaging in the PLF learning activities.

NH-PRE also correlated at a medium level with both the number of posts (RQ, .353) and the time to deadline (TTD, .479). Insofar as both of these indicators are a sign of student participation in the PLF activities from quantitative (RQ) and qualitative (TTD, assuming starting to work earlier in the week leads to better quality participation) standpoints, then this observation is consistent with the above-mentioned link between NH-PRE and OSE/PLF+ measures. This relation needs to be further investigated to be confirmed or refuted.

Let us now consider the OSE/LH+ indicator; it has a small negative correlation (-.111) with the PRO-SDLS self-efficacy factor and a negligible one with the overall PRO-SDLS score (.011). The correlation with the number of posts (RQ) was also negligible (.021), while the correlation with the time to deadline (TTD) was the highest (.337). These observations indicate that students whose pre-survey answers led to a high OSE/LH+ indicator value are also students who start working on their assignments earlier in the weekly routine. Insofar as activities described in the OSE/LH+ responses choices are time-consuming (e.g. searching for alternative explanations, re-doing non-graded exercises and exercises for which the students have already a solution...), it is sensible to expect students who give themselves more flexibility and time in dealing with the multiple weekly learning activities to be the ones who will actually have the resources to engage in those activities.

## **Major Findings and Discussion**

We conclude with a review of the major findings and contributions of our study along with some reflections on its scope and its alignment with an appropriate methodology to contribute to the field of computing education research.

### **Usefulness of our new “auxiliary” self-efficacy measures**

This paper contributed several instruments aimed at capturing various facets of students' self-efficacy. This section will review the ones we deemed “auxiliary” for both peer learning forums and learning habits perspectives before discussing the main measures with respect to each of these in the following section.

As far as observed self-efficacy with respect to the peer learning forums (OSE/PLF), both the number of questions posted by the deadline (RQ) and the average time to deadline for the first question post for

each student (TTD), turned out to not be directly usable as measures of self-efficacy in the way students use the PLF. However, they allowed us to capture specific aspects of this usage which, in turn, helped formulate hypotheses about the relation between the main indicators.

Observed self-efficacy with respect to the students’ learning habits (OSE/LH) had a single auxiliary indicator in the number of hours students indicated devoting to a typical 3 credit hour course. This correlated significantly with both the main OSE/PLF+ and OSE/LH+ measures (respectively .527 and .595). As such, it stands out as a relevant indicator of some aspects of students’ self-efficacy in this course. We view its primary use as a means to provide mentoring to students. In the past semester, results of preliminary studies of student learning habits have been shared with students taking the class during the following semester. This approach, which we have yet to evaluate formally, is meant to provide feedback to students on their learning strategies in a more formal way. Statistics are derived each semester and shared with the class via Blackboard’s announcements. Shortly thereafter another announcement repeats the general guidelines from the syllabus and illustrates them with practical examples showing correlations between certain learning habits and other course factors. It is our hypothesis that such feedback will have more weight than simply warning students ahead of time about typical pitfalls they might not see before it is too late.

### Usefulness of and relations between our three self-efficacy measurements

In addition to the “auxiliary” measures of self-efficacy we proposed in this paper, with the success discussed in the above section, we also proposed two main instruments to complement self-efficacy measures obtained with the PRO-SDLS.

The first instrument is described in Table 2 and allowed us to score students’ participation in peer learning forums in terms of positive and negative indicators of observed self-efficacy with respect to peer learning forums (respectively named OSE/PLF+ and OSE/PLF-). The second instrument was based on a single multiple-answer question which asked students to identify their learning habits; selection of one or more answers we deemed indicative of self-efficacy resulted in a single value from 0 to 7 we termed OSE/LH+.

	PRO-SDLS	PLF		LH
	SE factor	OSE/PLF+	OSE/PLF-	OSE/LH+
SE factor		-0.552	0.566	-0.111
OSE/PLF+	<b>-0.552</b>		-0.820	0.079
OSE/PLF-	<b>0.566</b>	<b>-0.820</b>		0.053
OSE/LH+	-0.111	0.079	0.053	

Table 11 – Summary of correlations between self-efficacy measures from Table 7 (N=14)

Table 11 summarizes the correlations between these three instruments as follows (taken from Table 7): The PRO-SDLS’ self-efficacy factor is negatively correlated to both OSE/PLF+ (-.552) and OSE/LH+ (-.111),

while logically positively correlated to OSE/PLF- (.566). In addition, OSE/LH+ is not significantly correlated to either OSE/PLF+ and OSE/PLF-. These observations indicate that the three main instruments we used (PRO-SDLS, OSE/PLF and OSE/LH) capture different aspects of students' self-efficacy:

- The PRO-SDLS' self-efficacy factor, since it is based on an attitude survey, captures the students' self-perception of their own self-efficacy in a manner which is discipline-agnostic.
- The OSE/PLF is an indicator biased by instructors' perspectives on how students' questions on forums reflect their engagement with the material (e.g. reading assignments, hands-on programming experimentations) and learning activities based on what they need to do to be successful programmers
- The OSE/LH indicator is also an instructor's perspective on what kind of learning activities students should engage in to be successful learners in an online asynchronous programming course.

As such, these three instruments need to be combined to help the instructor acquire a perspective on students self-efficacy in his or her class, which is more than what each individual instrument would provide. We believe that, while the combination of instruments used in this paper is not to be considered as optimal, it motivates further research on discipline-specific measures of self-efficacy as well as research on how to de-tangle misleading self-images regarding self-efficacy which students might have when taking a course which is highly demanding in self-direction (by its contents and delivery format) for the first time.

These measures also suggest new ways to identify, early in a course, students who might require some closer mentoring regarding their learning strategies. For instance, a student with a high SPSE might be easily mentored to improve their OSE/PLF, students with opposed SPSE and OSE/LH might be confronted with the contradiction of their answers in order to help them adapt their learning habits... While such monitoring and interventions are not content-specific, the instruments to alert the instructor about their necessity should probably be content-specific, in the light of the findings described in this paper.

### **A sample ideal for case studies**

Beyond the points we already discussed, we believe that this study constitutes a good example of one in which qualitative methodologies (e.g. case study) are far more informative than quantitative ones. We believe this to be due mainly not to the methodologies or instruments we used but rather the specifics of our student population. The USFP IT department has many non-traditional students: full time worker, have been in the workforce for a while, often over-committed by taking up to 5 classes on top of a full time job, only taking courses to obtain a degree as fast as possible in order to facilitate promotion at their current workplace, etc. We coined the term "overcommitted adult learner" to characterize this student subpopulation and draw attention to the fact that, unlike more traditional students, they might be devoting an even smaller portion of their time to engaging in learning activities. From our instructor's

perspective, computing education research studies published with statistical significance over a large population sample often fall short of being useful simply due to the differences between the surveyed populations and our students. In comparison, critical case studies focused on student populations sharing intrinsic characteristics with our own students are much more informative in guiding our teaching practice and better understanding our students' learning barriers.

This experience of ours guided our choice to leverage qualitative methodologies to single out what makes our student population unique and to reflect on how we can affect it. We are still early in this process but have successfully devised instruments which have helped us gain insight into our students' differences when being measured using existing instruments or pedagogies which have been studied in other settings. Our experience so far led us to realize that most of these instruments are actually providing us a biased picture which is more relevant to understand the "strategies" *our students are using when taking our classes* rather than cognitive aspects of their learning; e.g., extremely well performing students stopping working after accumulating 70 points, since their objective is merely to pass the class, poorly performing students who participate regularly in all activities which might provide points while not focusing on learning how to program, etc.

These "strategies" are to be the focus of following studies as they appear only as "noise" in most instruments aimed at measuring cognitive aspects of students' learning behaviors. If we are to separate their impact from the view we have on students' learning, we need to be able to isolate them and address them with pedagogical strategies in a manner similar to how we address more content-based learning barriers.

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