The Preternship – An Academic-Industry Partnership Model for Early Experiential Learning Experiences in Computer Science Curricula

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Abstract – **Herein, we present the "Preternship", an experiential learning method for introducing industry projects in the classroom early in the CS curricula. We conduct surveys of 132 industry members and 39 faculty members, and compare the results to assess opportunity for experiential learning. Then, we present the format and post-program survey results of a Preternship for a 48-student introductory computing course and a 16-student junior/senior level VLSI course, working in tandem with 27 industry Mentors, to demonstrate the potential for implementing this program early in CS curricula. The survey results show significant potential for the Preternship as a model for enhancing student skills in project planning and execution, motivating students to remain in their program, and showcase their technical and leadership potential to employers.**

Index Terms – Experiential Learning, Preternship. Spiral Software Development Model.

INTRODUCTION

Computer Science and Engineering (CSE) undergraduate programs are increasingly being called upon to prepare larger and more-diverse student populations in both CSE and non-CSE fields due to computing's increasing cruciality to innovation across a wide range of interdisciplinary problem domains. U.S. academic institutions grant approximately 90,000 bachelor's degrees in computing fields every year, but the number of computing jobs are increasing by 145,000 annually [1]. Federal investigative committees, such as the National Academies of Science and Engineering [2], the National Science Foundation [3], and the Department of Defense [4] have identified the need for CSE departments and industry to develop new partnerships to help meet workforce needs and continue to graduate well-prepared students.

However, industry leaders are increasingly expressing concern that CSE graduates are not obtaining critical skills necessary for entry into the labor market. Recent studies have shown a significant difference between industry and academia's assessment of graduates' technical, skills, particularly in project planning [5]. A 2015 study by the National Association of Colleges and Employers of 318 U.S. employers [6] found that the top five abilities valued by industry were communication, teamwork, ethics, critical thinking, and the ability to apply knowledge. The study concluded that students may possess the necessary technical qualifications, but they often lack the ability to navigate large and complex problems.

Most CSE programs limit real-world experiential learning opportunities to senior Capstone design projects, internship practicums, or research experiences for undergraduates. These projects are often small and self-contained, limiting the utility of the approach and the ability of project-based learning to provide students with hands-on experience relevant to numerous critical project management concepts. Furthermore, studies have shown that 88% of CSE students feel that real world problem solving should be applied in the first semester of study in computer science [7]. Sixty percent of students who leave the CS major will do so by the end of their first year in the program [8], and the second-most commonly cited reason is the perception that their coursework has little connection to the real world.

Studies have shown that internships and cooperative education (co-op) have impacts on a student's capability to develop a course of action based on the understanding of a whole system, compare and judge alternate outcomes, and ensure that process or product meets a variety of technical and practical criteria [9]. However, these same studies show these programs have a negligible impact on a student's capability to apply fundamentals new problems, develop lifelong learning strategies, or identify critical information. Therefore, providing opportunities for students to apply curriculum fundamentals to real-world problems within a classroom environment is essential for meeting the needs of the modern CSE workforce.

Expanding those opportunities within CSE curricula is difficult, as the pressures and demands felt in CSE departments and their universities are real, severe, and current [10]. Implementing project-based learning and experiential learning in introductory courses requires identifying opportunities for slack within courses early in CSE curricula so that time spent on project design and industry interaction does not force other instructors to take up the burden of teaching additional material. Therefore, in order for academic programs to promote increased real-world experience through professional practice as recommended by industry leaders, rigorous and longitudinal assessment of the efficacy of strategies, tactics, and support systems for institutions to respond to these needs in the short as well as the long term must be investigated, especially those taken or considered in terms of high enrollments.

Industry has recently indicated a need for students who are familiar with process development models. A study of IT professionals [11] found a desire for improved understanding by graduates for process models. Much of the focus of implementing process models in undergraduate education has been on the Agile Software Development Model [12-15]. Recent events, such as the Boeing 737 Max disasters [16], have shed light on the need for graduates with experience in process development models. Anecdotally, there is growing urgency for finding employees with these skills, particularly in government and defense sectors.

PRETERNSHIP FORMAT

In this section, we outline the format and justification for the Preternship program. We note here that the UCCS Noyce Scholarship uses the term "Preternship" for competitive short-term *on-site* experiences for prospective professionals considering a career in that field [17]. We define **Preternship** here as an academic-industry partnership where students are taught research and project planning skills *in the context of the current course*. Employer generally enjoy experiential learning because they use project work as a "proxy" for the skills they were looking for in candidates [18]. The primary difference between the Preternship and other experiential learning opportunities [19-21] is that they are offered as Senior Capstone or Cooperative Learning opportunities. By focusing on experiential learning early in the curriculum, we aim to address the fact that most CS students who leave the major do so early in the program and cite lack of real-world experience.

I. Industry Mentor Recruitment and Participation

Industry mentors, referred to as **Preternship Mentors**, provide the opportunity for interaction with students, as well as guidance on a project. The mentorship is designed to require a minimal time footprint. The mentors are asked to perform three tasks:

1. Submit a paragraph during the first few weeks of the semester describing how they are using computing principles in their workplace on a regular basis.
2. Create a 30-minute time frame to be interviewed by the student team during the assigned week for interviews, and provide feedback for their questions.
3. Provide a brief review of the project proposal.

First, we reached out to potential industry mentors through the University of Notre Dame Career Services Center. For the recruitment, we indicated that they could either serve as a mentor or participate in the baseline survey assessing perceptions of the capabilities of recent engineering graduates (the results of that survey may be found in the next section and Tables I-III).

We make two notes here. First, the responsibilities for assign the final projects to the students, as well as managing code reviews and project development ultimately fall to the professor. We will discuss the mechanisms for this later in this section. Second, in our recruitment of potential mentors, that we emphasized that we wanted to minimize the footprint and expectations of the mentors, and that we wanted to avoid projects that required access to Intellectual Property or classified material. These assurances greatly increased our pool of potential mentors.

For this iteration of the program, we implemented the Preternship in two courses: Introduction to Computing for EE (48 students) and the VLSI System Design (16 students). Those students had a total of 28 Preternship Mentors (21 for Intro to Computing, 7 for VLSI). The companies represented by industry mentors were: Amador of America, Amazon, AT&T, Cadence Design Systems, Cisco, Collins Aerospace, Evergreen Coast Capital, GE Current, GE Healthcare, General Motors, Glidepath, Google, IBM, Intel, Keystone Resorts, Lenovo, Micron Technologies, MITRE, Naval Nuclear Laboratories, Orro, Panasonic Automotive, ProstheTech, Rapid7, Raytheon, RCM-X, ShotTracker, Timbredio, Torigen, and WabTech.

II. Project Selection and Initial Interview

We compiled the list of descriptions from the mentors, and then allowed students to bid on working with companies whose work they found interesting. Students could rank and bid on up to 5 projects. We developed a program that sorted students into projects based on their bids. The priority for selections were based on two factors

- In-class coding participation score.
- Student project priority ranking.

After running the assignment algorithm program, 92% of students were assigned to a project that was one of their top-3 selections.

Once assigned, the students sent an email to their Preternship Mentor, using a professional template, to request their 30-minute interview timeslot. The teams are required to submit as an assignment a set of 7-8 questions based on their review of the paragraph and independent background research on the topic. During the interview, the students receive feedback, and then use these answers to develop a project proposal.

At the same time that students were able to bid and be assigned to projects, I assigned course TAs to each project to serve as **Preternship Project Managers (PM)**. The purpose of allowing students to serve as Project Managers is to provide an opportunity for honing leadership skills within a real-world construct. The PMs led the weekly code reviews detailed in *IV. Code Reviews*, provided mentorship and feedback to the students, and observed the final project demonstrations. For the Introduction to Computing course, there were six Preternship Project Managers.

III. Project Proposal

Based on their interview and feedback, the students develop a project proposal. At this stage, students are taught the Spiral Software Development Model [22]. Students are taught the importance of identify the initial objectives, assessing risk and potential alternatives, product development, and testing, and how the correct approach is to re-asses the objectives, risk, and alternatives to improve the product development.

The initial project proposal from the teams were required to include the following:

- Introduction Statement giving an overview of their project plan.
- A set of Definitions, which are key words someone new to the project would need to understand in order to understand the rest of the project.
- Design Considerations, including the Assumptions, Project Requirements, Initial Risks and Alternatives, Description or Artifacts, and Required Items.
- Project goals and an initial timeline.

IV. Weekly Memorandums and Code Reviews

During the main project duration, which is the final four weeks of the semester, the student teams work on their project. While the Preternship is underway, the entirety of out-of-class work is focused on the Preternship Project, in order to prevent overburdening the students and the TAs.

Each week, the student teams meet with the Preternship Project Manager to perform a Code Review. The students demonstrate the current status of the code to the mentor, and compare the status of the code with the objectives from either the Project Proposal (Week 1) or from the previous week's code review. The students discuss risks and challenges that arose from development of the product. If the risks are such that the objectives need to be revisited, the students will develop the next spiral.

The student teams report their progress each week to the Preternship Mentors, Project Managers, and professor through weekly Memorandums. Each memorandum includes the set of met objectives, as well as any proposed modifications and new spirals since the last week. The Mentors are not expected to respond to the Weekly Memorandums.

V. Final Deliverables

During the Final Exam Week, the students schedule an appointment to present their work to their mentors. These presentations were often accomplished via teleconference. The students make a 10-minute Powerpoint presentation, and then demonstrate their code. After the presentations, the Project Managers and professor develop a final grade. Students are then asked to send a thank you letter expressing gratitude to the service of the Mentors.

Industry and Academic Baseline Surveys

Before we began the Preternship program, we conducted two baseline survey to determine the perceptions of computer science students and graduates, as well as students from engineering disciplines in general.

I. Baseline Industrial Survey

In this section, we present the results of the baseline study industry members on the perceptions of recent science and engineering graduates. We received 132 responses. Of those respondents, 23.7% have been in the workforce less than 5 years, 26% had worked for 10-15 years, 20.6% have been in industry for 15-20 years, and 29.8% have served for more than 20 years.

In Tables I-IX in this manuscript, the tabulated data and calculated values are represented by the following symbols:

- 1-5: The score given by the respondent
- x' – The Average of the scores
- M – The Median of the scores
- s – The Standard Deviation of the scores
- σ^2 - The Variance of the scores
- CIL – 95% Confidence Interval Low
- CIH – 95% Confidence Interval High

In Table I, the industry survey questions were as follows: **In general, what is your perception of recent college graduates' capabilities to meet modern professional needs in terms of**:

A. Relevant professional/technical skills.
B. Professionalism and Workplace Etiquette.
C. Written Technical Presentation Skills.
D. Verbal Technical Presentation Skills.
E. Leadership Skills.
F. Ability to accept/act upon critical assessments of work.

TABLE I
INDUSTRY BASELINE SURVEY – PART I

Q	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	8	29	81	14	3.8	4	0.7	0.5	3.6	3.9
B	1	8	47	56	20	3.6	4	0.8	0.7	3.5	3.8
C	3	24	57	39	9	3.2	3	0.9	0.8	3.0	3.3
D	4	25	57	40	6	3.1	3	0.9	0.8	3.0	3.3
E	7	18	55	43	9	3.2	3	0.9	0.9	3.0	3.4
F	1	9	50	54	18	3.6	4	0.8	0.7	3.5	3.7

In Table II, the industry survey questions were phrased as follows: **In general, what is your perception of recent college graduates' capabilities to contribute to and complete planning and execution of projects in terms of:**:

A. Completion of research and/or independent tasks with minimal supervision.
B. Familiarity with project process models.
C. Development of project requirements in advance of implementation.
D. Consider the objectives and constraints of all success-critical stakeholders.
E. Identify and evaluate alternative approaches for satisfying objectives and constraints
F. Develop interfaces between project components, as well as identifying and resolving interface mismatches prior to implementation.

G. Identify and resolve risks that stem from the selected approaches, including developing thorough test cases, and unit and integration testing.
H. Communication of project progress to project leaders.

TABLE II
INDUSTRY BASELINE SURVEY – PART II

	1	2	3	4	5	x'	M	s	σ²	CIL	CIH
A	0	18	44	64	6	3.4	4	0.8	0.6	3.3	3.5
B	11	37	61	21	2	2.7	3	0.9	0.8	2.6	2.9
C	6	42	59	25	0	2.8	3	0.8	0.6	2.6	2.9
D	9	46	59	17	1	2.7	3	0.8	0.7	2.5	2.8
E	4	33	53	36	6	3.0	3	0.9	0.8	2.9	3.2
F	4	31	67	26	4	2.9	3	0.8	0.7	2.8	3.1
G	8	53	50	21	0	2.6	3	0.8	0.7	2.5	2.8
H	1	22	34	44	3	3.2	3	0.8	0.7	3.0	3.4

In Table III, the industry preliminary survey questions were phrased as follows: **In your experience, how important are the following student experiences to your assessment of their employability and capability to excel in the workforce:**

A. Reputation of University / Department where they received their degree.
B. Professional Internship
C. Cooperative Education (Co-Op)
D. Apprenticeships
E. Undergraduate Research / Field Study
F. Senior Capstone experience
G. Completion of quality classroom projects which demonstrate necessary technical skills.
H. Independently completed projects which demonstrate necessary technical skills.
I. Leadership and Involvement in Student Organizations
J. Well-balanced Liberal Arts Education

TABLE III
INDUSTRY BASELINE SURVEY – PART II

	1	2	3	4	5	x'	M	s	σ²	CIL	CIH
A	13	28	34	40	17	3.1	3	1.2	1.4	3.0	3.4
B	2	11	21	45	53	4.1	4	1.0	1.0	3.9	4.2
C	12	22	45	38	15	3.1	3	1.1	1.2	3.0	3.4
D	17	19	44	39	13	3.1	3	1.2	1.3	2.9	3.3
E	5	23	42	44	18	3.4	3	1.0	1.1	3.2	3.5
F	9	21	36	45	21	3.4	3	1.1	1.3	3.2	3.5
G	2	10	36	57	27	3.7	4	0.9	0.8	3.6	3.9
H	0	7	22	56	47	4.1	4	0.8	0.7	3.9	4.2
I	9	17	36	51	19	3.4	4	1.1	1.2	3.2	3.6
J	6	20	27	36	15	3.3	3	1.1	1.2	3.1	3.5

II. Baseline Faculty Survey

We received 39 responses from faculty members of the College of Engineering at the University of Notre Dame. Of the 38 respondents, 9 were from Computer Science and Engineering (23.1%), 9 were from Aerospace and Mechanical Engineering (23.1%), 8 were from Chemical and Biomedical Engineering (20.5%), 7 were from Civil and Environmental Engineering (17.9%), and 6 were from Electrical Engineering.

Of the responding faculty members, ten had taught less than 5 years, eight had taught 5-10 years, ten had taught 10-20 years, five had taught 20-30 years, and six faculty had taught more than 30 years. Seventeen respondents (43.6%) worked in industry before joining the faculty.

In Table IV, the faculty preliminary survey questions were phrased as follows: **In general, what is your perception of current engineering student's graduates' capabilities in the following soft skills:**

A. Complete tasks independently.
B. Implement established processes correctly.
C. Understand project requirements.
D. Evaluate multiple approaches to a problem.
E. Identify risks.
F. Communicate design process/progress in writing.
G. Break a large project into smaller tasks.
H. Work as part of a team.
I. Utilize skills from non-major courses in engineering coursework.
J. Develop emotional intelligence.
K. Lead a team.
L. Apply major-specific concepts to entreneurship.
M. Communicate design process/progress in a presentation

TABLE IV
FACULTY BASELINE SURVEY – PART I

Q	1	2	3	4	5	x'	M	s	σ²	CIL	CIH
A	6	11	13	7	1	2.6	2.5	1.0	1.1	2.3	3.0
B	1	6	14	13	4	3.3	3	1.0	0.9	3.0	3.6
C	4	15	11	8	0	2.6	2	0.9	0.9	2.3	2.9
D	13	13	8	4	0	2.1	2	1.0	1.0	1.8	2.4
E	1	10	13	10	4	3.2	3	1.0	1.0	2.8	3.5
F	2	18	13	4	1	2.6	2	0.8	0.7	2.3	2.9
G	1	5	11	14	7	3.6	3	1.0	1.0	3.2	3.9
H	2	13	22	1	0	2.6	3	0.6	0.4	2.3	2.8
I	2	13	12	10	1	2.9	3	1.0	0.9	2.6	3.1
J	4	5	23	5	1	2.8	3	0.8	0.8	2.6	3.1
K	8	6	16	8	0	2.6	3	1.0	1.1	2.3	3.0
L	3	4	11	14	6	3.4	3	1.1	1.2	3.1	3.8
M	5	9	14	6	4	2.9	3	1.2	1.3	2.5	3.2

Next, we asked the faculty members to rank their priorities as an educator/professor. Table V shows the average (x'), median (M), standard deviation (s), and 95% Confidence Interval Low and High (CIL and CIH). The ranks are from highest priority (1) to lowest priority (12). The final priority ranking from the survey are as follows, as sorted by average:

A. Teaching students the course material
B. Enhance critical Thinking through problem solving
C. Provide a solid understand of theoretical concepts
D. Preparing students for post-graduate success
E. Engaging students with the course material
F. Teaching students major-specific skills
G. Teaching students how to recover from failure
H. Giving students the opportunity to collaborate
I. Reaching out to traditionally underrepresented groups
J. Enhancing communication of major-specific skills
K. Teaching students how to use industry tools
L. Enhancing communication of non-major skills

TABLE V
FACULTY BASELINE SURVEY – PART II

Priority	x'	M	s	CIL	CIH
A	3.36	2.00	2.7	2.30	4.41
B	3.82	3.00	2.3	2.92	4.72
C	4.14	3.50	2.6	3.15	5.14
D	4.75	5.00	2.7	3.71	5.79
E	5.04	4.50	3.0	3.85	6.22
F	5.39	5.00	2.8	4.29	6.50
G	6.50	6.50	3.2	5.25	7.75
H	6.79	7.00	2.3	5.90	7.67
I	8.29	8.00	2.2	7.43	9.14
J	9.14	10.00	2.0	8.38	9.90
K	9.64	10.00	2.2	8.79	10.50
L	11.14	12.00	1.4	10.62	11.67

II. Analysis of Baseline Survey Results

The faculty respondents indicated that their top priority was to teach students the course material. Likewise, the highest-ranked perception of recent graduates from industry was their relevant technical/professional skills (3.8). The second-highest ranked education priority of faculty respondents was enhancing critical thinking through problems solving. However, the perception of the skills of recent graduates by industry pertinent to problem solving, project development, and testing (Table II.D-II.G) were significantly lower (2.75 average).

A finding that shows the potential for the Preternship program is that the second-highest mark for "importance of student experiences" was "Independently completed projects which demonstrate necessary technical skills" (4.07). One industry respondent said, "I value the ability to independently complete a project as highly as an Ivy League education." A commonly-cited challenge for assessing the employability of an applicant was determining if they actually did the work in group projects cited on the resume.

Employers stated that students who lacked internship or cooperative education experiences by their senior year would have a difficult time raising their perception through completion of a Senior Capstone project. Not only does this explain the relatively low score (II.F, 3.4) compared to classroom projects (II.E, 3.7) and independent projects, but shows an example of why students tend to leave earlier in the CS curriculum. Students are perceived to be less hirable early in their academic careers only fall further behind, a phenomenon which disproportionally affects women and underrepresented groups [23, 24]. The Preternship has the potential to provide students an opportunity to build skills that reflect well on them in a classroom environment.

POST-PRETERNSHIP SURVEY

After completion of the Preternship pilot program, we designed and conducted three post-Preternship assessment suverys. The first was sent to the 27 Mentors to assess their perceptions of how the Preternship contributed to the student's capability, their ability to conduct project planning and execution, and how they view the Preternship compared to other factors in assessing a potential employee. The questions in the survey are outlined in *Section I. Industrial Partner Survey*, and the results are presented in Tables VI, VII, and VIII.

We note here that, since most of the Preternship Mentors were Notre Dame alumni and were assessing Notre Dame students in this survey, we added the following statement to the survey with the objective of removing bias towards favoring students at their alma mater:

- **Comparison Groups** - For your assessment, please compare your Preternship students with past interns from the following groups as closely as possible:
- *For Intro to Computing for Electrical Engineers* - Notre Dame/Sophomore/Electrical Engineering Major as appropriate.
- *For VLSI System Design* - Notre Dame/Junior or Senior/Computer Science/Computer Engineer/Electrical Engineer as appropriate

The second survey was sent to the student participants from the two pilot courses. Forty-two of the students (67.7%) responded to the survey. The survey assessed the student's enthusiasm for computing compared to the beginning of the semester, as well as their perception of how the Preternship contributed to the development of skills desired by employers compared to the beginning of the semester. The questions in the survey are outlined in *Section II. Student Participant Survey*, and the results are presented in Tables IX and X.

The third survey was sent to the student participants who served as Preternship Project Managers. All six students who served in this role responded to the survey. The survey assessed the student's enthusiasm for computing compared to the beginning of the semester after participating as a Project Manager. The questions in the survey are outlined in *Section III. Preternship Project Manager Participant Survey*, and the results are presented in Table XI.

I. Industrial Partner Survey

The questions and survey results for the Preternship Mentor Survey are detailed below in Tables VI-VIII:

Part 1 - Student Capability. (Table VI) Compared to students or professionals at a similar level to the students you worked with during the Preternship, what is your perception of the capabilities of the students you mentored to meet modern professional needs in terms of:

A. Relevant professional/technical skills.
B. Professionalism and Workplace Etiquette.
C. Written Technical Presentation Skills.
D. Verbal Technical Presentation Skills.
E. Leadership Skills.
F. Ability to accept/act upon critical assessments.

Part 2 - Project Planning and Execution. (Table VII) Compared to students or professionals at a similar level to the students you worked with during the Preternship, what is your perception of the capabilities of the students you mentored to contribute to and complete planning and execution of projects in terms of:

A. Completion of research and/or independent tasks with minimal supervision.
B. Familiarity with project process models.
C. Development of project requirements in advance.
D. Consider the objectives and constraints of all success-critical stakeholders.
E. Identify and evaluate alternative approaches for satisfying objectives and constraints
F. Develop interfaces between project components, as well as identifying and resolving interface mismatches prior to implementation.
G. Identify and resolve risks that stem from the selected approaches, including developing thorough test cases, and unit and integration testing.
H. Communication of project progress to project leaders.

TABLE VI
POST-PRETERNSHIP MENTOR ASSESSMENT SURVEY – PART I

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	2	2	12	9	4.1	4.0	0.9	0.7	3.8	4.5
B	0	0	2	6	17	4.6	5.0	0.6	0.4	4.4	4.8
C	0	0	4	11	10	4.2	4.0	0.7	0.5	4.0	4.5
D	0	0	2	17	6	4.2	4.0	0.5	0.3	3.9	4.4
E	0	0	10	10	5	3.8	3.0	0.7	0.6	3.5	4.1
F	0	0	4	10	11	4.3	4.0	0.7	0.5	4.0	4.6

TABLE VII
POST-PRETERNSHIP MENTOR ASSESSMENT SURVEY – PART II

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	0	1	12	12	4.4	4.0	0.6	0.3	4.2	4.7
B	0	0	5	9	11	4.2	4.0	0.8	0.6	3.9	4.5
C	1	0	2	10	12	4.3	4.0	0.9	0.8	3.9	4.6
D	0	1	1	15	8	4.2	4.0	0.7	0.5	3.9	4.5
E	0	0	9	6	10	4.0	4.0	0.9	0.8	3.7	4.4
F	1	0	5	13	6	3.9	4.0	0.9	0.8	3.6	4.3
G	1	1	6	9	8	3.9	4.0	1.0	1.1	3.5	4.3
H	0	1	0	9	15	4.5	4.0	0.7	0.5	4.2	4.8

Part 3 – Project Planning and Execution – (Table VIII) Compared to students or professionals at a similar level to the students you worked with during the Preternship, provide your assessment of the employability and capability of a student who completed a Preternship to excel at a professional internship compared to the following factors:

A. Reputation of University / Department where they received their degree.
B. Cooperative Education (Co-Op).
C. Apprenticeships.
D. Undergraduate research / Field study.
E. Senior Capstone.
F. Completion of quality conventional (non-Preternship) classroom projects which demonstrate necessary technical skills.
G. Independently completed projects which demonstrate necessary technical skills.

II. Student Participant Survey

The questions and survey results for the Student Participation Survey are detailed below in Tables IX-X:

Part I – Enthusiasm - Compared to the beginning of the semester, describe how the Preternship contributed to your enthusiasm for:
A. Using computing in your career.
B. Implementing the advanced principles learned in the course in your career.
C. Continuing in your chosen major field.
D. Combining concepts learned outside the class, as well as the coding and design principles, towards creative or entrepreneurial pursuits.
E. Implementing design models for improving the engineering process in your career.

TABLE VIII
POST-PRETERNSHIP MENTOR ASSESSMENT SURVEY – PART III

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	2	7	3	7	6	3.3	3.0	1.3	1.7	2.8	3.8
B	4	3	7	7	4	3.2	3.0	1.3	1.7	2.7	3.7
C	2	4	9	6	4	3.2	3.0	1.1	1.3	2.8	3.7
D	1	5	4	11	4	3.5	3.0	1.1	1.2	3.0	3.9
E	1	6	6	6	6	3.4	3.0	1.2	1.4	2.9	3.9
F	0	2	1	12	10	4.2	4.0	0.8	0.7	3.9	4.5
G	1	1	6	9	8	3.9	4.0	1.0	1.1	3.5	4.3

TABLE IX
POST-PRETERNSHIP STUDENT ASSESSMENT SURVEY – PART I

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	4	18	13	7	3.6	3	0.9	0.8	3.3	3.8
B	0	6	14	20	2	3.4	3	0.8	0.6	3.2	3.7
C	0	3	15	16	8	3.7	3.5	0.9	0.7	3.4	4.0
D	0	3	13	19	7	3.7	4	0.8	0.7	3.4	4.0
E	0	5	10	15	12	3.8	4	1.0	0.9	3.5	4.1

Part 2 – Capability/Understanding - Describe how participation in the Preternship project contributed to your ability/understanding of the following, compared to the beginning of the semester:
A. Written Technical Presentation.
B. Oral Technical Presentation.
C. Development of project requirements in advance.
D. Ability to accept and act upon critical assessments.
E. Completion of research and/or independent tasks with minimal supervision.
F. Familiarity with project process models.
G. Consider the objectives and constraints of all success-critical stakeholders.
H. Identify and evaluate alternative approaches for satisfying objectives and constraints.
I. Develop interfaces between project components, as well as identifying and resolving interface mismatches prior to implementation.
J. Identify and resolve risks that stem from the selected approaches, including developing thorough test cases, and unit and integration testing.
K. Communication of project progress to project leaders.

III. Preternship Project Manager Participant Survey

The questions and survey results for the Preternship Project Manager Participation Survey are detailed in Table XI:

TABLE X

POST-PRETERNSHIP STUDENT ASSESSMENT SURVEY – PART II

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	1	10	22	9	3.9	4.0	0.7	0.5	3.7	4.2
B	0	2	16	19	5	3.6	3.5	0.8	0.6	3.4	3.9
C	0	1	3	26	12	4.2	4.0	0.7	0.4	4.0	4.4
D	0	0	8	22	12	4.1	4.0	0.7	0.5	3.9	4.3
E	0	0	8	22	12	4.1	4.0	0.7	0.5	3.9	4.3
F	0	0	6	26	10	4.1	4.0	0.6	0.4	3.9	4.3
G	0	1	6	26	9	4.0	4.0	0.7	0.5	3.8	4.2
H	0	0	5	28	9	4.1	4.0	0.6	0.3	3.9	4.3
I	0	2	9	20	11	4.0	4.0	0.8	0.7	3.7	4.2
J	0	0	10	20	12	4.0	4.0	0.7	0.5	3.8	4.3
K	1	0	5	21	15	4.2	4.0	0.8	0.7	3.9	4.4

Enthusiasm - Compared to the beginning of the semester, describe how serving as a Preternship Project Manager contributed to your enthusiasm for:

A. Using computing in your career.
B. Combining concepts learned outside the class, as well as the coding and design principles, towards creative or entrepreneurial pursuits.
C. Implementing design models for improving the engineering process in your career.
D. Serving in leadership and mentorship positions.
E. Providing mentorship as a Code Reviewer in improving internal code quality and maintainability.
F. Providing mentorship as a Code Reviewer in transferring knowledge about the codebase, solution approaches, expectations regarding quality, etc; both to the reviewers as well as to the team.
G. Providing mentorship as a Code Reviewer in provided constructive feedback regarding student user and technical documents for completeness and clarity.
H. The diversity of opportunities for applying computing principles, as well as leadership opportunities.
I. Importance of a well-balanced liberal arts education.

TABLE XI

POST-PRETERNSHIP PROJECT MANAGER ASSESSMENT SURVEY

	1	2	3	4	5	x'	M	s	σ^2	CIL	CIH
A	0	0	0	5	1	4.2	3.5	0.4	0.1	3.9	4.5
B	0	0	2	1	3	4.2	3.0	0.9	0.8	3.4	4.9
C	0	0	0	3	3	4.5	3.5	0.5	0.3	4.1	4.9
D	0	0	0	0	6	5.0	3.5	0.0	0.0	5.0	5.0
E	0	0	0	1	5	4.8	3.5	0.4	0.1	4.5	5.1
F	0	0	0	1	5	4.8	3.5	0.4	0.1	4.5	5.1
G	0	0	0	1	5	4.8	3.5	0.4	0.1	4.5	5.1
H	0	0	0	2	4	4.7	3.5	0.5	0.2	4.3	5.0
I	0	1	4	1	0	3.0	2.5	0.6	0.3	2.5	3.5

POST-PRETERNSHIP RESULT ANALYSIS

I. Results and Analysis of Survey Data

For this analysis, we note that the respondents were asked to compare to a previous, such as how their perceptions of previous interns or how they felt compared to the beginning of the semester. If they responded 3, the respondents felt considered it exactly the same. If they responded 5, they assessed significant improvement.

The Preternship Mentor respondents showed enthusiasm for the project compared to similar students. They indicating that the students showed higher technical skills (4.1), professionalism (4.6), and written and oral presentation skills (4.2) compared to similar students. They also indicated the students had a higher capability in independent work (4.4) and implementation of process models (4.1). problem solving, project development, and testing (4.1). They also indicated that, now that they are familiar with the Preternship, they would consider completion of a Preternship on a similar-level to a Co-op (3.1) or Apprenticeship (3.1), and slightly higher than a classroom project (3.4) or a Senior Capstone (3.5) when evaluating their employability.

The students showed a relative improvement in enthusiasm for using computing in their career (3.6), continuing in their chosen field (3.7) and combining concepts towards independent pursuits (3.8). Their self-assessment relating to problem solving, project development, and testing averaged to a 4.1. Five students from the Introduction to Computing for EE course indicated that they received an offer of an internship directly from their Project Mentor.

The Preternship Project Managers overwhelming showed enthusiasm for serving on the project, and felt their experience improved their CS education experiences. Three of the six mentors received Project Manager internship offers with 2 months of completion of the program. We reached out to those hiring managers, and they indicated the experience on their resumes made a significant difference in being able to not only assess their technical skills, but also their technical and leadership potential. We note here that all three hires were minorities, and two of the three were women, and the hiring manager's choice of "potential" to be critical, since studies show that men are more likely to be considered in terms of their potential, whereas women are more likely to be considered by their current accomplishments [25].

II. Opportunities for Improvement and Future Work

In the Spring 2020 semester, the Preternship will be implemented in the CSE 20312 Data Structures course. There are a total of 178 students in the course. We currently have 71 industry volunteers to serve as Mentors. Furthermore, 17 students will serve as Preternship Project Managers this semester. In this section, we will discuss comments and criticisms from the student participants, either through the survey or from the Course Instructor Feedback at the end of the semester, and how that will contribute to modification of the Preternship program.

There are still plenty of opportunities for improvement. For future iterations of the Preternship, we will ask the Mentors to provide a brief sentence describing a potential project. The aim of this approach is to focus the student/Mentor interviews, and minimize the frustration of the students at the beginning of the process.

Student satisfaction was anecdotally proportional to the level of participation of the industry Mentor. For future iterations of the Preternship, we will standardize the opportunities that students and Mentors will interact to maintain fairness between projects.

Recruiting mentors from non-CS/CPEG/EE programs greatly improved the diversity of potential projects, which the students appreciated. However, we must provide safeguards to ensure that these mentors understand the student's capabilities. Providing a syllabus was insufficient since those mentors were not familiar with CS curricula, unintentionally leading to excessive expectations. Furthermore, we will more strongly emphasize to the students that they have a level of agency to decide the direction and scope of the project.

To reduce communication overhead, we will ask student groups to update their Project Proposals and Memorandums through a shared Google folder. Using the Google Folder will also aid in standardizing student/Mentor interactions.

Conclusions

We presented an approach to experiential learning at the introductory level in computer science curricula called the "Preternship." We outlined the format, provided pre- and post-assessment surveys from industry members, academia, student project participants, and teaching assistants serving as Project Managers. We found that the pilot program for the Preternship demonstrated significant potential for improving undergraduate preparation for modern technical challenges. Survey results reflect the potential for use of the Spiral Software Development Model in enhancing student skills in project planning and execution, meeting a clear and rising need in industry. The survey results show that industry participants familiar with Preternship mode show interest in offering those students internships.

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