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Development of a Novel Graduate Pedagogy to Enhance Job Readiness in Semiconductor Education Based on Role-Playing Internship Experience

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Session XXXX

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Abstract

There is a high demand for jobs in the semiconductor manufacturing sector due to the Chips Act. With this high demand there is a need to increase job readiness for graduate students specializing in this area. Semiconductor industry members feel that current graduate students are not well prepared to transition from academia to industry and often need several years of experience before they add value to the company. Current graduate academic education pedagogy prepares students for research and academia positions but often falls short of preparing students for industrial careers in manufacturing. Students can get the needed experience through internships, but this is not always possible due to location, research time constraints, citizenships, and academic time commitments. To try and overcome this challenge we are developing a novel two course program, where the first course aims to mimic a semiconductor/microsystem industry internship, and the second semester aims to mimic a microsystems startup company. This will be accomplished through "role-playing" courses where students act as interns in the 1st semester (onboarding) and then they transition to employees in the second semester, and instructors act as Managers/bosses. The courses use problem-based learning (PBL) in a nanofabrication cleanroom environment as the test vehicle. The courses are designed to give students hands-on experience to provide them with the knowledge, skills, and abilities (KSA) that are needed in industry. The KSA's were determined and ranked from an industrial panel survey consisting of process engineers to upper management and from multinational companies to start up companies. This allowed the "instructors" to determine which KSA's to focus on in the course.

Introduction

Mainstream graduate STEM education programs are traditionally designed to train students for academic careers as they focus on knowledge and skills related to laboratory research practices, writing technical journal papers, and presenting results at conferences to academic peers. This method of education has value in preparing students for academic careers but falls short in preparing them for industrial careers by not providing them with the necessary KSA demanded by industry [1-3]. Talking to recent graduates that have gone on to work in industry, almost all agreed that transitioning from academic environment to industry was difficult, which they were not well prepared. Most academic instructors have followed the traditional academic career path (BS->MS->PhD->Post-Doc->Professor) and have no or very limited industrial experience, and they teach based on their experience and skills. However, most graduate students do not go on to have academic careers but instead join the industrial workforce. Therefore, students are not getting the KSA's that are needed, and traditional teaching methods are not providing graduate students with industrial culture. This issue is rapidly increasing due to the increase in coursework-only MS degrees, as students in this category get little hands-on experience except for courses with labs. There have been numerous attempts to increase job readiness by bridging the gap between industry and academia but with only limited success [4-7]. Therefore, there is a need to first identify the key KSA's that industry desire MS/PhD students to have when they graduate, and then once they are identified we need a method to teach these KSA while developing a method simulate industrial culture to ease students transition from academia to industry.

This paper describes a novel method to overcome these challenges by creating a multi-course curriculum aimed at mimicking hands-on industrial experience while in an academic environment through "role-playing." This paper briefly describes the concept and overview of the courses as well as disseminating some of the initial results from the industrial panel survey to identify key KSA's in the semiconductor/microsystems manufacturing sector.

Concept Overview and Methodology

The authors have previous experience in enhancing semiconductor training for technicians for undergraduates [8] as well as developing novel lab-based courses to enhance graduate education [9]. The concept to enhance job readiness that was investigated includes creating an industrial environment for graduate students by having them and the instructors participate in a role-playing course. First the authors identified key KSA's that industrial members thought needed to be addressed, which was achieved through surveying an industrial panel. The overall project consists of two mandatory courses, where course 1 mimics an internship and course 2 will mimic a start-up company. Combining these courses will give students some mock industrial experience which we believe will enhance their KSA enabling them to get a job quicker and to provide value to the company earlier. Both instructors have significant industry experience which allows them to provide firsthand experience to the students. Students will get essential skills by working in teams as well as leadership experience and management skills which are often lacking in students.

The first semester consisted of onboarding the students/interns, which consisted of training them on equipment in the cleanroom, and then they had to use their training to fabricate devices including diodes, art wafers as a product for a customer, and develop bimorph actuators. During the 1st course students got trained on cleanroom equipment, methodology, product development, communication skills (written and oral), statistics, and various other KSA identified below. The second course will focus more on product development, where "students" will use their onboarding skills from the first semester course to actually develop MEMS devices. For instance, the second semester course will focus on developing a microfabrication foundry for pressure sensors, where students will need to design, fabricate, and characterize various pressure sensors while increasing yield and decreasing cost.

Initial Survey Results

Before the start of the course, we surveyed n=10 industry members which had a range of job titles from Process engineer to upper management. All industry participants had at least three years of experience and some had >20 years of experience in semiconductor/microsystems. The panel included members from different states, so they were not basing their answer on a single university curriculum. However, some panel members were former students at UNM so they knew the current curriculum. The survey consisted of n=47 questions regarding KSA's that can be broken down in six categories: essential skills, technical skills, fabrication skills, design, statistics, and emerging skills. The panel members were asked to assign a score from 1-4, where four meant that the KSA was critically needed and not currently taught in academia, a 3 meant the KSA was needed, a 2 represented that academia already do a good job of teaching the topic, and a 1 meant the KSA was not needed in industry.

Out of 47 questions that were assessed the industry panel deemed 19 (40.4%) of them that needed to be addressed to enhance job readiness. This means that the industry panel thought 59.6% of the KSA's surveyed were either not critically important for the job or that universities already do a sufficient job of teaching those KSA's. The categories that the industry panel thought needed to be addressed were Statistics and Testing, Technical skills, and Essential skills. The top individual KSA's were statistical process control (SPC), process capability index (CP), and experience with industrial culture each scored a rating of 3.625 out of 4. The lowest ranked items belonged to the fabrication skills category as the majority of panel members thought universities already do a sufficient job of teaching them theory, such as oxidation and doping theory.

Based on the industry review panel results we developed the course to highlight KSA development in at least half of the 19 subjects identified by the panel as needing to be addressed. The other half of the subjects will be addressed in the second course. The first course on mimicking an internship experience was taught in Fall 2024. We successfully recruited six students to participate in the course. Since this course takes place in the cleanroom participation was limited to <8 students per semester for safety reasons. All six participants were MS students, and the students had various backgrounds in mechanical engineering, electrical engineering, or computer engineering. Five of the students had no prior experience working in a cleanroom and all participants had no prior semiconductor industrial experience. Evaluation results comparing the student's growth and comparison to other students will be reported in future studies. But initial results show significant growth in knowledge, skills, and abilities.

Summary and Conclusions

The study in this paper is a "Work in Progress" as only initial results from the industrial panel survey are presented in this paper. The paper briefly described the concept of creating a new pedagogy for interdisciplinary graduate education aimed to increase job readiness. The concept of creating an internship experience in an academic environment was developed using semiconductor/microsystems as the test vehicle, but the concept could potentially be applied to other industrial work experience, but semiconductor manufacturing was used because of its high demand

and its multidisciplinary nature. The initial results from the industrial survey indicate that industry members feel there are areas where academic graduate education falls short of preparing students for industrial jobs. Future results will evaluate student experience and learning in both courses and compare the results to students with and without internship experience.

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