

Formative Evaluation of an Innovative Program to prepare non-technical majors to join advanced manufacturing workforce

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Abstract— The manufacturing industry has been thriving recently after decades of defection offshore and outsourcing. The manufacturing industry in the state of Massachusetts is particularly strong. Massachusetts and other US states report shortage of enough skilled workforce to fill advanced manufacturing positions such as robotics operators, programmers, CNC programmers, CAD operators, and QA personnel, to name a few. The labor shortage is attributed to the lack of STEM pipeline of students who are interested to pursue STEM careers including manufacturing. This paper describes an innovative approach of how to re-train non-technical majors (liberal arts graduates) for a second career to join the manufacturing workforce. The paper focuses on the formative evaluation of the approach. It covers the evaluation instruments including survey forms, data collection, data analysis, and insightful conclusions. The formative evaluation is conducted by a professional external evaluation organization and administered to the first cohort in a three-year NSF funded program.

Keywords— *advanced manufacturing; workforce labor needs; second career; formative evaluation*

I. INTRODUCTION

Recent reports have shown that advanced manufacturing have been going strong in multiple regions of the country [1]. On the other hand, other reports also show that there is a shortage in workers who qualify for open positions in the field of advanced manufacturing [2].

While there is a shortage for skilled workers in advanced manufacturing, an opposite problem exists. That is the high percentage of un- or under-employed among recent liberal arts

(BA) graduates known as the mal-employment problem in non-technical majors [3]. The mal-employment of this segment of population rose by 9.3% during the recent recession [4].

These two problems complement each other. That is if we can find a way to re-train and prepare recent BA graduates to fill vacant positions in advanced manufacturing, we would succeed to solve both problems.

The TRANSFORM program, funded by 3-year NSF grant, is set to test this hypothesis and offers a solution. The program recognizes that BA graduates have an excellent foundation already by the virtue of their BA degrees. What they lack are technical skills in advanced manufacturing. Thus, we can train them in a short period of time.

This paper provides a brief overview of the TRANSFORM program to set the paper context. It then focuses on the formative program evaluation during the first year of the program. We also discuss the changes we have made to the program as a result of the program formative evaluation.

II. PROGRAM OVERVIEW

The program [5, 6] offers a 12-month stackable curriculum in advanced manufacturing with two tracks: manufacturing technology and manufacturing innovation. The technology track prepares BA graduates for jobs such as CAD operator, CNC programmer, production supervisor, and robotics operator to name a few. The innovation track prepared BA graduates for jobs such as customer service, sales, social media analysis, and accounting to name a few.

The certificate requires three semesters and 25 hours. Students take full course load in two of the three semesters. They go on internships in the third semester to hone their newly-acquired technical skills before they assume full employment in the advanced manufacturing field. Internships

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also help increase the employability chances of the students. The details of the curriculum have been already published [6].

The internship is mandatory and each student must finish a minimum of 80 hours of work to graduate. This requires the program staff to secure internships for every students enrolled in the program. Towards this end, the program staff worked extra hard to recruit local employers who can provide internships. These internships go far beyond the required 80 hours. They typically last for 4-6 month to allow the employer to train the students and reap the benefits of their investments.

III. STUDENT ENROLLMENT

We have recruited and enrolled the first cohort of the TRNASFORM program in the 2015 spring semester. The cohort consists of 10 students with different demographics and backgrounds. Some are recent BA graduates; others are looking to change career paths. Some are females; others are males. Some are BA graduates; some come with technical associate degrees. And yet, some come with high school diploma. This cohort is not uniformly BA recent graduates, but a mix. This mix reflects the different levels of interests and motivation of population in general. It also reflects our resources of reaching out to the population.

IV. EVALUATION INSTRUMENTS

The TRANSFORM program is evaluated by an external professional evaluator, SageFox Group. The evaluator performs two tasks. First, it design all evaluation instruments and conducts the formative and summative evaluations. Second, it seeks IRB approvals from the academic institution before contacting the human subjects to perform the evaluations.

In our case, approval was granted by the IRB office at MassBay Community College where the TRANSFORM program is being implemented. The new protocol application submitted to the MassBay IRB Board included the Purpose (goals) of the Study, the logic model that forms the basis of the evaluation process, the Study Procedures, the Participant Selection, Risks, Benefits, Data Analysis and Monitoring, Data Storage and Confidentiality, and Informed Consent Process. All these are detailed in the application to allow the IRB Board to make informative decisions. We focus on the evaluation forms in this paper.

The evaluation instruments focus on evaluating the curriculum, its courses, and the advising and student support system. It also focuses on evaluating the internship system and internships. Accordingly different forms have been designed and used. Students must voluntarily agree to participating and filling the forms before filling them.

The curriculum related survey has the following 20 sections:

1. What is your name?
2. Which certificate are you working towards?
3. How many credits have you completed at MassBay?

4. What previous colleges/universities have you attended, if any?
5. Did you earn a bachelor's degree? Why/why not?
6. How did you hear about the TRANSFORM manufacturing certificate program?
7. What attracted you to the TRANSFORM manufacturing certificate program?
8. What do you hope to get out of the TRANSFORM manufacturing program?
9. Please rate (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) the extent to which you agree with the following statements:
 - a. I am doing well in my courses
 - b. The courses are well designed
 - c. The schedule of courses fits into my personal schedule
 - d. I am getting the support I need to be successful in my courses
 - e. I have gained skills that have better prepared me for a job in the manufacturing field
 - f. I am confident I can get a good job in a manufacturing field after I complete the program
 - g. I would like a career in a manufacturing field
 - h. This program is meeting my expectations
 - i. For all items selected "disagree" or "strongly disagree": Please explain your answer
10. Which of these course formats work well for your schedule? (Yes, No, Do not know):
 - a. On-campus
 - b. On-line
 - c. Hybrid
11. Which of these course formats work well for your learning style? (Yes, No, Do not know):
 - a. On-campus
 - b. On-line
 - c. Hybrid
12. Do you plan on continuing next semester? Why/Why not?
13. As a result of the training received through the Certificate program, what changes have you seen in the following:
 - a. My confidence in my ability to propose a solution for a given problem
 - b. My confidence working collaboratively to propose a solution for a given problem
 - c. My preparedness to use appropriate terminology to describe problem-solving approaches to stakeholders
 - d. My technical knowledge (applications of computers, CAD and 3D printing and scanning)
 - e. My knowledge of quality control rules and methods of continuous improvement
 - f. My understanding of the role of standards in the manufacturing process.

14. How have your views on a manufacturing career changed since beginning the certificate program?
15. How has the career awareness/preparation offered through the program contributed to this change?
16. How often do you meet with your advisor?
 - a. Never/Rarely
 - b. About once a semester
 - c. About twice a semester
 - d. Monthly
 - e. Weekly
17. Advising is an important part of this program. If you have any additional comments about your advising experience please provide them here.
18. What has been the best part of your experience in the certificate program thus far?
19. What has been the most challenging part of your experience in the certificate program thus far?
20. Do you have any suggestions for the program moving forward? Please be specific, this information helps refine the program for you and future students.

Other similar surveys are designed for evaluating student internship experience. Three internship surveys are designed: one to be filled by the student, one by the student industry supervisor, and one by the student faculty advisor at MassBay.

The last evaluation instrument is a focus group meeting. The external evaluator selects randomly some students and meet face-to-face with them, ask them questions, and record their answers. The focus group protocol begins as follows:

Before we begin our discussion, we would like to let you know that:

- You are not required to participate in this interview. You may decline to answer any questions we ask, and you may request to end the interview at any time;
 - We will be recording and taking notes during the discussion; and
 - We will not quote you by name in our report to NSF.
- Do you agree to participate in this interview under these conditions? Do you have any questions?

The focus group protocol questions are listed below:

Focus Group Protocol – Part A

1. How did you learn about the TRANSFORM program?
2. Why did you decide to enroll?
3. What is your academic background?
4. What is your background knowledge/experience related to manufacturing?
5. What excites you about the program?
6. What do you think will be your greatest challenge?
7. What have been the best and worst parts of the program to date?
8. What types of STEM supports have been most valuable to you? (Clubs, organizations, activities, groups)?
9. What are your career plans?

Focus Group Protocol – Part B

1. What have been the best and worst parts of the program?
2. Did you feel like you were able keep up with the pace of the program?
3. Were you able to fully participate in courses or was there prerequisite information you felt you were missing?
4. What types of STEM supports have been most valuable to you? (Clubs, organizations, activities, groups)?
5. MassBay offers courses in a variety of formats and during days, evenings or on weekends to meet the needs of both part time and full time students. What type of scheduling has proved most convenient and useful to you?
 - a. Mostly days
 - b. Evenings
 - c. Weekends
 - d. Online
 - e. Online Hybrid (lecture in class, lab on campus)
6. Did you participate in the internship this year?
7. How have you changed your career goals since starting TRANSFORM (if at all)?
8. Is there anything missing from the TRANSFORM experience?
9. How might the program be improved for future students?

Many of the above questions have probes to guide the discussion of the focus group. These probes are not listed here due to the space limits.

V. PROGRAM FORMATIVE EVALUATION

The evaluator conducted the evaluations using the evaluation instruments. The evaluator met with students, and TRANSFORM faculty. The evaluator also administered all the on-line surveys including from industry internship supervisors. The evaluator then extracted the data from the surveys, compiled them, and ran statistical analyses using specialized software such as Tableau. The evaluator wrote their reports and submitted them to the TRANSFORM leadership team for action. The evaluator also met face-to-face with the team to discuss the evaluation findings.

VI. FORMATIVE EVALUATION RESULTS

The evaluation results revealed eye-opening facts to the TRANSFORM team. All ten participants responded to the various surveys, for a 100% response rate. All participants are in the manufacturing technology certificate program. The following key findings and conclusions are the students recommendations to change the TRANSFORM program:

Joining the Program

Half of the students learned of the TRANSFORM program through their local career or unemployment office. Most of these students had completed some undergraduate credits but had not earned a bachelor's degree. The rest of the students learned of the program through their personal or academic connections to MBCC. Students were attracted to the program for the employment possibilities, the internship experience and the duration of the program (one year). The quality and

convenience of the program was also an appeal. Most students hope the program will lead to a job, though the students with a Bachelor's degrees are more inclined to say they joined the program in hopes of affecting a future "career" compared to those without, who are looking for a "job."

General Satisfaction

About half of students agree that the program has been living up to their expectations and six of the ten thought the courses were well-- designed. Two of the students disagree and three are neutral that the program is meeting expectations. Clearly, there is room for improvement. Still, when asked if they would continue with the program next semester, all students said yes except for two who will have completed the coursework and are seeking internships.

Students Recommendations and suggestions:

Internships: Students are discouraged by not securing internships. At the time of the survey, 6 of the ten students secured internship. As of writing this paper, only two students are looking to be replaced.

The conclusions from the focus group meeting echoed similar findings to those found in the surveys. Mainly, the lack of internships is the major hurdle to students. It should be mentioned here that some students are to blame for not securing an internship, as one student put it: "Some students are weak in personal presentation skills. It is hard to watch someone complain about not getting an internship when they wear sneakers to meet with employers."

On the curriculum side, one student recommended: "I think it would be better to replace coding classes CS101 A,B with GD&T and Solidworks classes to go to advanced levels of training. When I reading job descriptions on Designer/Drafter jobs and manufacturing sectors I can see how they looking for proficiency in Designer/Drafter job for manufacturing in qualified applicants. no one ask for coding. Last but not least, if it possible please provide some reference material for student."

VII. EVALUATION-BASED PROGRAM CHANGES

As a result of this formative evaluation, we plan the following changes for the next academic year:

1. Relax the internship requirement: we make the internship optional instead of being required. We will continue to seek industry partners to provide internships. If a student wants to pursue an internship, they could the requirement by working 80 hours minimum. This may also relieve employers from both the financial burden and the time committed.
2. Relax the computer coding sequence of course. There are four 1-hour courses: CS101 A-D.

Currently they are all required. We will require only one, CS101-A, and make the other three electives.

VIII. TESTING THE CHANGES

These curriculum changes must be submitted to various academic committees at MassBay for approval. Once approved, they will implements with the second cohort of students who will begin the program in the Fall 2016. Another formative evaluation will be conducted at the end of the second year with the second cohort to seek their feedback for implementation in the third and final year of the program.

IX. CONCLUSION

The paper presents the formative evaluation of an innovative new model to address the mal-employment of BA graduates. the evaluation revealed interesting results that the TRANSFORM team is implementing by making changes to the TRANSFORM curriculum for evaluation in the following academic year.

REFERENCES

- [1] "Strengthening the Innovation Ecosystem for Advanced Manufacturing", Pathways & Opportunities at Massachusetts MIT Industrial Performance Center, May 2015
- [2] Supply Chain News: German Firms Take US Skill Shortage into Own Hands, Launch Manufacturing Training Programs Here. Staff, Supply Chain Digest Editorial. 2012, Supply Chain Digest, pp. <http://www.scdigest.com/ontarget/12-07-11-1.php?cid=6002&ctype=content>.
- [3] Neeta P. Fogg and Paul E. Harrington, "Rising Mal-Employment and the Great Recession: The Growing Disconnection between Recent College Graduates and the College Labor Market", Drexel University, Continuing Education, Vol. 75, (2011).
- [4] Rana Foroohar, "Forget Unemployment, Time to Worry about 'Mal-Employment'" on *Time*, October 2013
- [5] Zeid, A., Javdeka, C., Bogard, M., Steiger-Escobar, S., Moussavi, S., Valerie Kapilow, Elizabeth Watson, Duggan, C., Kamarthi, S., "A Hybrid and Modular Curriculum Model in Advanced manufactur-ing for Liberal Arts Graduates", Accepted, Int'l J. Eng. Education.
- [6] Zeid, A., Javdekar, C., Bogard, M., Steiger-Escobar, S., Moussavi, S., Duggan, C., Sullivan, D., Kamarthi, S., "Addressing the Problem of Unemployment and Underemployment of Liberal Arts Graduates", IEEE FIE Conference, Oct. 21-24 El Paso, Texas, 2015.