Journal of Language and Education Policy
ISSN:2691-6061 (Print)2691-607X (Online)
Issue: Vol. 2; No. 5; August 2021 pp. 16-19
Website: www.jlepnet.com
DOI: 10.48150/jlep.v2no8.2020.a3

FUNCTION-ORIENTED-TOOL-BASED LEARNING FOR ADDITIVE MANUFACTURING IN VIRGINA STATE UNIVERSITY SUMMER CAMP

Heng Li
Department of Applied Engineering Technology
Virginia State University
E-mail: hli@vsu.edu

Benedict Uzochukwu
Department of Applied Engineering Technology
Virginia State University
E-mail: buzochukwu@vsu.edu

Abstract

The dominant methods for engineering education are still lecture-based teaching, although the "chalk-talk" method is not effective. Accreditation orders and job market expectations ask for more student-centered methods to teach. In the fields of engineering, the integration of problem and project-based learning is called for by accreditation agencies. First, in this study we provide a teaching model, Function-Oriented-Tool-Based Learning (FOTBL), which is a combination of lectures and projects, especially emphasizing the unity of action and knowledge. The FOTBL focuses on one tool or equipment in a period of teaching time with a systematic integration of learning its functions and working on its components. In this teaching model, teaching content is driven by the student's inquiry "How does this tool produce this wonderful product?", "What is inside the tool?"The reason to use a tool as a learning base is that any advanced tools are always an embodiment of the integration of modern advanced technologies. Obviously, the FOTBL may attract and stimulate students with advanced industry technology, and provide students with industry practices, as fabricating the products with the tool, and allows students to learn fundamental theory actively. Then, the study provides a PBL course design and the influence of advanced equipment support to fulfil objectives of learning. Finally, we present an initial implementation of the FOTBL for learning additive manufacturing technology in Virginia State University summer camp.The camp is evaluated based on the student's survey. It shows that the FOTBL method can stimulate students' interest in engineering fields and improve students' learning abilities.

Keywords: Engineering Education, Problem-Based Learning, Project-Based Learning, 3d-Printing, Student-Centered Methods, Lecture-Based Learning

Introduction

According to the U.S. Department of Education, only 28% of undergraduate students in the U.S. are under 21 and attend 4-year schools. A recent survey in 2017 [1] reported that only 34% of the universities and colleges met student enrollment targets, down from 42% just two years ago. In this paper, we explored the teaching models in engineering education and provided a new teaching methodin order to attract more students into engineering fields. The dominant methods for engineering education are still lecture-based teaching, although the "chalk-talk" method is not effective.Engineering education is in the midst of a paradigm shift, from lecture-based learning to the integration of problem- and project-based learning (PBL) [2]. Accreditation agencies and engineering professionals have called for this change[3]. This call requires to revise curricular and instructional approaches in engineering programs andto reconstruct their courses and teaching methods to incorporate problem-and project-based learning. Although the instructional methods in engineering education typically have been traditional and teacher-centered, research studies over the past decade indicate a change towards learner-centered curricula [3]. There are many types of PBL learning in the fields of engineering in literature.In this study we creat a teaching method, Function-Oriented-Tool-Based Learning to respond to the call.

The pedagogical method was applied in Virginia State University Summer Camp in 2019, 2020 and 2021 to attract students to enroll in our Pipeline program. The application of the method can efficiently solve current problems in engineering education. In reference [3], Mills listed six critical issues in engineering education:

1. Engineering curricula are too focused on engineering science and technical courses without providing sufficient integration of these topics or relating them to industrial practice. Programs are content driven.
2. Current programs do not provide sufficient design experiences to students.
3. Graduates still lack communication skills and teamwork experience and programs need to incorporate more opportunities for students to develop these.
4. Programs need to develop more awareness amongst students of the social, environmental, economic and legal issues that are part of the reality of modern engineering practice.
5. Existing faculty lack practical experience, hence are not able toadequately relate theory to practice or provide design experiences. Present promotion systems reward research activities and not practical experience or teaching expertise.
6. The existing teaching and learning strategies or culture in engineering programs is outdated and needs to become more student-centered.

The FOTBL can help to solve the issues in engineering education listed above.We used this method in Virginia State University summer camp for middle and high school students to learn additive manufacturing. The results showed the impact of the FOTBL on stimulating students' interests in engineering fields and improving students' learning abilities.

Materials and Methods

In the FOTBL method, instructor chooses an advanced equipment or tool. First, students learn how to run the tool and make products. Then, the students take apart the tool into components to learn the functions and geometry of every component of the tool. Further, they put the components back to install the tool, do their own projects to improve the tool, and give a presentation in groups. For example, for learning advanced manufacturing, it is obvious to choose a 3D-printer as a tool. 3D Printing or additive manufacturing is a process of making three-dimensional solid objects from a digital file. Therefore, in order to fabricate simple 3D-products, students first have to learn to design the 3D modeling of objects using software. Then, taking part a3D printer allows students to learn the geometry and functions of every components of the printer, such as temperature sensor, extruders, stepper motors, filament, print bed, heat system, etc [6]. Finally, students put back the components to make a 3D-printer of their own. In 3D printing process, generally there are involved many basic engineering theories, such as 3D-modelling design, heat transfer, manufacturing processes, materials science, machine learning, machnical design, and electronic theory, etc.In the traditional teaching method, undergraduate students in engineering fields will learn these theories in different courses. Therefore, these courses are called content-driven courses. Although applications of theories isintroduced in these courses, they are still abstract and not fully attract to students. On the contrary, by using the FOTBL, student learn 3D-modeling design theory, driving by their desire to get the solid object they like to fabricate. As students see filament melting and extruding, and as students control the change of temperature during printing process, instructor teach heat transfer theory, such as heat conduction, convention, radiation. It is more efficient than that in traditional classroom. In addition, students learn how scientists and enginerscreatively transfer basic theories and techniques into advanced technology. They can always keep up with advanced technology in the FOTBL teaching model.

The FOTBL is a learning process based on one advanced equipment and tool, in which student's inquiry isoriented by the functions of the tool and naturally extends to its components. The learning process attracts and stimulates students to learn engineering fundamentals actively. The features of the FOTBL is exactly in agreement with the basic characters of Gold Standard PBL, which are shown in [5]:

1) Public product
2) Challengingproblem or question
3) Sustained inquiry
4) Authenticity
5) Student voice andchoice
6) Reflection
7) Feedback

8) Key knowledge,understanding, andsuccess skill

1) Public Product: it is obvious that a 3D printer can print out tangible geometry-complicated products, which will motivate and engage students with content. 2) Challenging question and problem:the students will naturally ask question "How does it make this wonderful product?"3) Sustain inquiry: over a period,the learning focuses on a 3D-printer and extends to its components to promote deeper questions. 4) Authenticity: the3D-printer technology is the advanced manufacturing technology. 5)Student voice and choice:students design and fabricate their products using the tool and working in groups. 6) Reflections: Taking apart a 3D-printer and putting it back by students allows them to reflect on their learning. 7) Feedback: students work in groups to get peer feedback, the final 3D-products give them feedback and 8)Key knowledge,understanding, andsuccess skills: 3D modeling, machine design, heat transfer, engineering materials, working as a team. Therefore, the FOTBL includes the essential elements of Gold Standard PBL.

In addition, the FOTBL can help to solve the six issues in engineering education listed above. It is obvious that the FOTBL may directly solve (1)(2), (3), (4), and (6). For (5), if an instructor wants to carry out the FOTBL method, they must learn advanced technology and tool constantly. This indirectly help to solve (5).

The limitation of the FOTBL is the accessibility of students to advanced tools and the capability of faculty of using the tools. The advanced tools always are an original integration of dynamic techniques and basic theories. This requires faculty members who use the FOTBL always update knowledge and skills. Developing the model to other fields depends on the character of the knowledge structure in that field. This method best fits in engineering technology field, not suitable for pure science major, as mathematics.

We implemented the FOTBL learning model in Virginia State University summer camp in 2019, 2020, and 2021. The purpose of the workshop is to stimulate high school and middle students' interest in engineering fields and to seek excellent studentsto enter STEAM Pipeline, a program funded by DOE. Our students in the summer camp were twenty high school and middle school students from the different states. Some of them were the third time to the camp. Our instructors were two high school teachers and six STEAM scholars. The two high school teachers with workshop experience wereselected from the local high schools. One was to teach website design, and the other is to help student to learn the basics of electronics and work on a project with 3D printing objects. Both teach one hour in the morning each day. The six STEAM scholars are our best students from EELT, INLT and MCET programs in the Department of Applied Engineering Technology. They taught the students 3D modeling design by using Tinkercad or Fusion 360 or Onshape. Each of the scholars took charge of three or four students. They were in the camp all day long. The four sets of 3D printers in our lab are Replicator Z18 Professional 3D Printer.

Results

We had a survey after the camps in which 80% of participants agree to learn the basic concepts of 3D-printing; 83.33% of the participants agree to like the engineering fields much more after completing the workshop; 100% of the participants agree to able to enroll STEM undergraduateprogram; 80% of the participants agree to attend the next summer workshop.

Discussions

Through using the FOTBL in the summer camp, we fulfill the objectives of our camp to stimulate high school and middle students' interest in engineering fields and to seek excellent students to enter STEAM Pipeline.In the future, we will develop this pedagogical method to different fields of engineering for undergraduate programs.

Conclusions:

This paperprovides the FOTBL learning method and PBL course design. It contains the essential elements of Gold Standard PBL. The method may help to reduce the critical issues in engineering education. It was used in Virginia State University summer camp 2019, 2020 and 2021 and fulfilled the objectives of the camp to stimulate high school and middle students' interest in engineering fields and to retain excellent students in theSTEAM Pipeline.

Acknowledgement: This study received funding by DOE (DE-NA0003867, 270136C).

References

1. [online] Available: https://www.insidehighered.com/news/survey/2017-survey-admissions-directors-pressure-all-around (2017)
2. Maria F G Wallace, Angela W. Webb (2016). In the midst of a shift: undergraduate stem education and "PBL" Enactment. Journal of College Science Teaching 46 (2): 47-55.
3. Mills, J. E., &Treagust, D. F. (2003). Engineering education—is problem-based or project-based learning the answer. Australasian Journal ofEngineering Education, 3, 2–16.
4. Krishnan, S., Gabb, R., &Vale,C. (2011).Learning cultures of problem-based learning teams. Australasian Journal of Engineering Education, 17(2),67–78.
5. Larmer, J., Mergendoller, J., &Boss,S. (2015).Setting the standard for project-based learning: A proven approach to rigorous classroom. ASCD Alexandria, VA USA
6. [online] Available: https://www.lpfrg.com/guides/3d-printing-concepts-and-3d-printer-parts/(2020)