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PRODUCING A HIGH EFFECTIVE ENGINEERING STUDENTS SUSTAINABLE LEARNING ENVIRONMENT DEPENDING ON PRODUCT INNOVATION AND DEVELOPMENT

Karar Ahmed Hamza[1], Mayadah W. Falah[1 b)], Doaa Falah Yousif[1], Zainab S. Al-Khafaji [2, 3, a)] and Sabaa S. Radhi[4]
[1]*Building & Construction Engineering Technology Department, Al-Mustaqbal University College, Babylon, Iraq*
[2] Al-Furrat Al-Awsat Distribution Foundation, Ministry of Oil, Babylon, Iraq.
[3] Al-Turath University College, Baghdad, Iraq
[4] Mechanical Engineering, Altinbas University, İstanbul, Turkey
Corresponding author: [a)] zainabcivil90@gmail.com [b)] Mayadahwaheed@mustaqbal-college.edu.iq

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Abstract:

This paper study one of the educational initiative which called Product Innovation and Development (PID). The PID aimed to produce a high innovation learning environment in order to focus on development and innovative products. This programme is specially focus on the ability of employing the undergraduate engineering students for developing and innovation new devices and products. And the students was put in groups in order to get the best and newest ideas from students where one of these group try to search about new ideas. As well as other students groups make analysis for market, design and produce the product, products selling and finally provide the customers with technical supporting. On the other hand, there is an estimation about the revenue of PID projects which could become self-sustainable in the future. Moreover, the project materials are used in different courses to enrich the curriculum and increase the impact of the projects.

Keywords: Product development, Bloom's taxonomy, Philosophy of engineering education

1. INTRODUCTION

A typical engineering technology curriculum in higher-education institutions should contain common body of knowledge (CBK) courses followed by technical courses in a specific major. In most programs the students have not an opportunity to employ in a real-world projects that involve all product development process aspects until the capstone/senior design courses in their senior year [1]. Since the lack of experience with real-world projects, many students majoring engineering technology have trouble understanding the gap between the material they learn in class and their expectations of engineering [2], [3]. This could contribute to the high attrition rate among engineering technology majors. To improve student learning and lower the attrition rate, The universities should invest heavily in seven activities [4]. These are:

- Enrich the students by preparing them for the workplace and real work via a high effect learning [5]–[14].
- Develop integrated interdisciplinary experiences for students.
- Enhance the core curriculum elements and findings thru technology and distance education [15].
- Enhancing the colleges opportunities to allocate credit by exam or for confirmation of competencies.
- Enhancing the outreach to PK-12 and community colleges so as to enhance college readiness.
- Enhancing faculty development in high impact, non-traditional, deep learning pedagogies [16], [17].
- Enhancing support for graduate students.

The majority of the funding should go to enrich the students by preparing them for the workplace and real work via a high effective learning and advising for toward progressing degrees. After realizing the important of a high effective learning environment for providing engineering technology students with product development experience in the real-world setting. The establishment of the Product Innovation and Development (PID) initiative [18].

2. HIGH EFFECTIVE LEARNING AND PID

Bloom et al. [19]–[21] introduced the concept of taxonomy for student learning. They categorized student learning into six levels, from basic to advanced: Creating, Evaluating, Applying, Analyzing, Understanding, and Remembering. Remembering is ability of calling the relevant information from long-term memory. Understanding is being able to

make sense of what one has learned. Applying earned into parts and understand how each part is related to the rest. Evaluating is being able to make judgements based on a set of guidelines. Creating is being able to put the learned knowledge together in an innovative way. While remembering and understanding the materials taught in class are crucial first steps in learning, it is critical that students have opportunities to apply, analyse, evaluate and eventually create their own design. These latter steps offer the student a chance to learn more in-depth and make an engineering technology major more attractive. While successful implementation of Bloom's taxonomy can be found in engineering majors [22].

Traditional teaching methods used in engineering programs have their limitations in higher learning levels in the categories of apply, analyse, evaluate, and create. Many courses in engineering curricula are too theoretical and do not provide enough real-world perspective. Educators are aware of this problem and proposed many new pedagogical platforms, like learning-based on problem solving, learning based on project preparing, collaborative learning, process oriented guided inquiry learning (POGIL), and peer-led team learning (PLTL) [23], in order to improving the situation.

While, to promote higher level student learning, many researchers proposed high impact practices (HIPs) work in 2008. HIPs include symposiums and practices from the first-year, intellectual popular experiences, learning groups, intensive courses writing, cooperative tasks and projects, graduation requirement research, variety and global learning, service learning/community-based learning, co-operative education/internships, and capstone courses and projects. Since 2008, many researchers conducted research in this area with promising results. There are similarities between both high impact learning performs and project-based learning; for instance, both emphasize experiential learning [24].

However, high impact learning is broader in the sense that it is not limited to traditional courses. Some of the HIPs, like intellectual popular experiences, learning groups, cooperative tasks and projects and graduation requirement research, can be effectively applied to engineering programs to provide intensive learning experiences for students. In addition to learning, there are other benefits from HIPs, such as retention rate improvement. While HIPs have proven effective in improving student learning in various aspects [25], specific majors still face implementation challenges. One of such challenges is funding the implementation of HIPs. This is more so the case when the HIPs are not part of the curriculum. The challenge is for PID to become self-sustainable. So, a focus area must be selected to create a high impact learning environment. The selected focus area must be appropriate for the unique Engineering Departments (ED) structure, the student body, faculty, and the available resources, as well.

3. CHOOSING OF THE FOCUS AREA FOR HIPS

Because of the close ties ED has with industry, the department is constantly seeking feedback from industry to enhance the curricula. One such finding from all three programs' boards industrial advisory was that the students' information and skilfulness in development product must be enriched. In order to make companies staying in competitive it is necessary to have a rigorous product development process and the employees must know how to follow the process [26]. After reviewing the feedback from industry and the current curriculum, ED faculty recognized a significant gap between what students could learn in school and the real work in an industry setting [2]. To minimize this gap, the ED program revamped the curriculum to convert the focusing to system and developing the products.

4. PID MISSION, ORGANIZATION, AND PROCESS

PID's mission has been initially established: The PID Initiative's objective is to create a high-impact, hands-on learning environment where students may improve interests and skills in product innovation based on real-world market demands. The purpose is to prepare university students to lead successful service and product innovation initiatives.
The organization of the PID Initiative is as follows: Steering Committee: consisting of the ED program directors. The steering committee provides general guidance in the direction of the PID initiative and determines the short-term needs for financial support before PID becomes self-sustainable. Working committee: consisting of four ED faculty members, and each program has at least one representative. The committee chair is rotated each year among the faculty member representing each program. Faculty advisors: consisting of faculty members with technical expertise and interests that match the specific PID projects. The faculty advisors are not permanent roles, instead, they are selected yearly based on the PID projects. Student researchers: consisting of undergraduate students within College of Engineering who are paid to work on PID projects. In addition, they work closely with instructors of relevant ED courses to design curriculum modules for educational purposes using the materials and experiences from the PID projects. They do not receive course credits for participating in PID projects.
There are two main focus areas in PID. One is the product innovation effort by students; the other is the educational modules developed by the PID students. These modules are used in relevant ED courses. The impact is two-fold: in depth for the student researchers involved in the PID project and in breadth for other students who benefit from the educational modules developed by PID student researchers. The PID process is shown in Figure 1. The starting point of the PID process is the creation of product ideas, which can be from students, faculty members, industry sponsors, idea competition ran by PID, and other funded external research projects. Interested students and faculty advisors then must evaluate the product ideas. A student team will be formed and a faculty advisor assigned to the team.

Student researchers then conduct business analysis, including market analysis, cost analysis, sales forecast, profit estimation, breakeven point analysis, estimation of initial investment needed, and estimation of return of investment. The feasibility report will then be submitted to the PID committee for final approval of establishment of a PID project. If the project is approved, the students will plan for the product development and potential curriculum application.

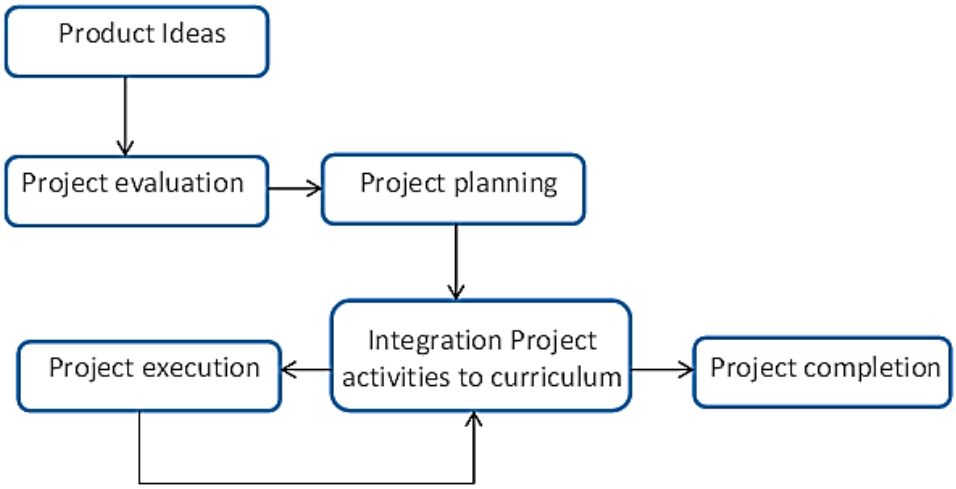

Figure 1. PID Product Development Process.

The design of the product will be carried out in parallel with the curriculum development efforts until the completion of the project. Although PID is not-for-profit, the expectation is that, in the long run, some successful PID projects will generate sufficient revenue to cover the cost and make PID self-sustainable. Therefore, PID student researchers must focus on both the financial aspect and the high impact learning aspect since PID needs the revenue to fund additional student researchers and new PID projects. This way, students working on PID projects get the full benefit of understanding how a business works. Financially, a PID project can be sponsored by faculty members, industry partners, and other external research project sponsors. As discussed earlier, resources needed for HIPs is one of the main challenges in implementation. To achieve self-sustainability, student researchers must execute PID projects as real-world business projects. This requirement brings the business and technical design together with multi-disciplinary efforts by the PID student teams. This is also an effective way to include the Industrial Distribution students who play a major role in the business aspect of PID projects. Not only do students get to work together in project teams, but faculty members from different programs also collaborate more

5. UNIQUE FEATURES OF PID INITIATIVE

As discussed earlier, HIPs have been implemented in many higher educational institutions. The PID Initiative has the following unique features:

1. The high impact learning is student-centered. Faculty members serving as advisors play secondary roles.
2. The high impact learning can be in a course or outside of ED courses. What the PID student researchers do is outside of the ED curricula. The educational modules they created are used in ED courses and provide learning opportunities for students taking these courses.
3. PID student researchers do not receive any course credits. They get paid for their work.
4. The PID projects are managed like a business. There are two distinct objectives: generating profit and making a positive impact on the curriculum.
5. PID student researchers learn every aspect of product development process.
6. The PID Initiative must be self-sustainable in the long run. If a project is not profitable in the long run, it will exit the PID project portfolio.
7. Most of the projects will be multi-disciplinary, typically including ID programs. In the context of Bloom's taxonomy for learning, PID projects involve the top five levels as indicated by the bold face font in Figure 2.

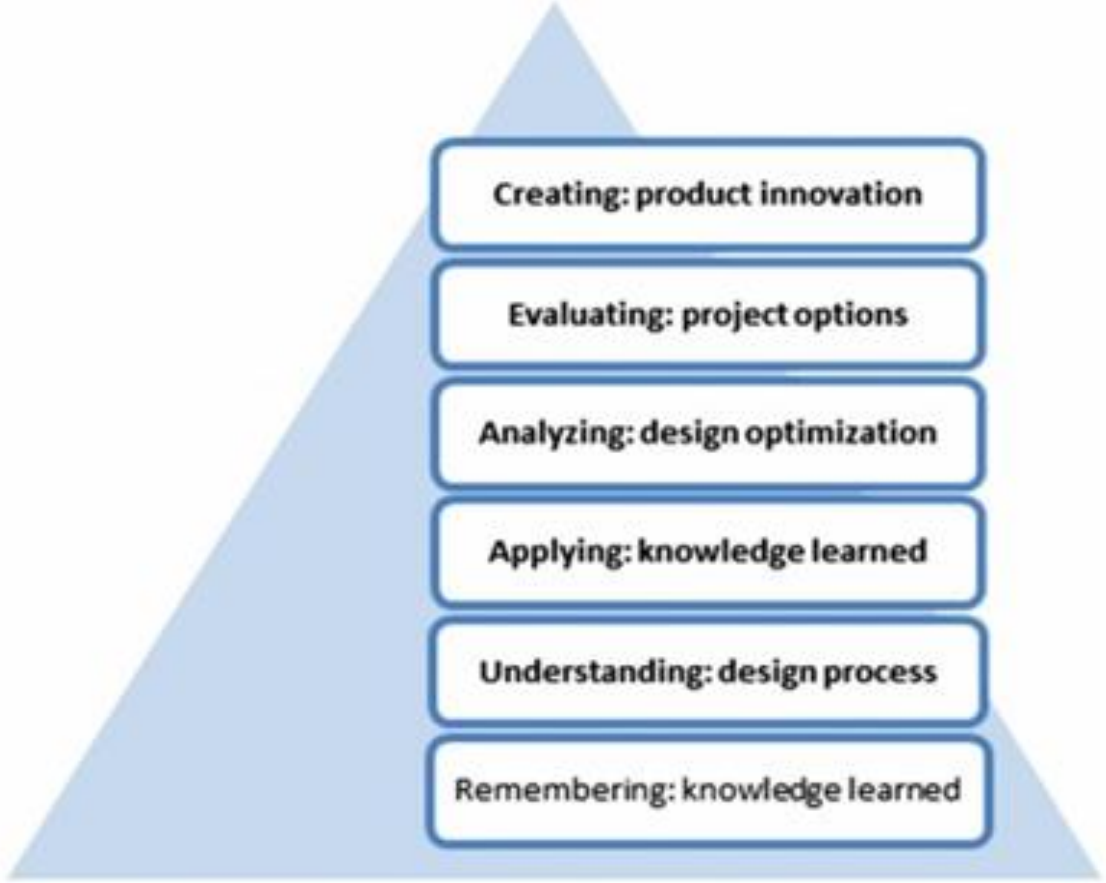

Figure 2. PID Project Activities in The context of Bloom's Taxonomy [20].

In the design process of PID projects, student researchers must make sense of what they learned in the technical courses they took from the ED curricula; this is the understanding part of the Bloom's taxonomy. Similarly, they have the opportunity to apply the knowledge they learned before in new ways during the design process. To optimize their design, which is necessary in order to maximize profit, students must have the ability to break the knowledge they learned into parts and understand how each part is related to the other parts. Evaluating occurs when the students and faculty advisors evaluate the feasibility of the project. It is also used when considering different options during the design phase of PID projects. Creating is thoroughly practiced because all PID projects involve product innovation. In summary, the top five levels of Bloom's taxonomy of learning are included in the PID projects [21].
The seniority of students hired to work on PID projects can vary from freshmen to seniors, which provides the opportunity for first-year experience for some freshmen. The PID teams provide opportunities for common intellectual experiences, learning communities, collaborative assignments and projects, and undergraduate research as well. The educational modules developed can be used in course projects and capstone projects. Therefore, many HIPs are available in PID projects, where a high impact learning environment could be created.

6. EVALUATION CRITERIA

Since the main objective of PID initiative is to enhance student learning, the evaluation of PID projects will focus on the educational aspect of the projects. To this end, the following metrics are established:

- Students' number impacted by the PID Initiative projects (breadth);
- Students' number researchers hired to work on PID projects (depth);
- Courses' number of impacted by the PID projects;
- Percentage of profitable PID projects;
- Overall balance of PID projects.

7. IMPACT Of PID ON STUDENT LEARNING

The first impact of PID initiative is the in-depth impact on the learning of the PID student researchers. For student researchers who will work on PID projects, the project and the PID initiative will provide them with opportunities of more in-depth learning. They will expose to many of the HIPs in the learning environment will create by the PID initiative. They will create innovative products, optimize their design, put together different information by learning from various courses, and work as teams consisting of students with different levels of experience. In addition to the technical skills, they will learn more about the product development process and many business aspects, which they usually do not get to see in ED courses. One of the important lessons the students will learn is that the success of a

product relies largely on marketing, sales, and other business aspects. The PID student teams are working together as a cohort to follow a new product development process. The student teams from multi-disciplinary backgrounds working on a common goal develop a holistic way of thinking. The students will face many challenges and oftentimes struggle to design, make, and sell their products. Every time they overcome a hurdle, they end up learning something new that may benefit them in their lifetime. The PID high impact learning environment is clearly different from a traditional classroom, where the knowledge acquired is most likely to be used for tests and assignments and rarely beyond the end of the semester. The PID student researchers are more likely to achieve higher level of accomplishment and retention because of the challenges they faced and overcame [27]. So far, the retention rate for PID students is 100%. It is expected that the PID projects create more competent students that are ready to face real-world challenges not only as engineers, but as the entrepreneurs and managers of the next generation.

8. CONCLUSIONS

The ED will create a high impact learning environment by employing students to develop innovative products. A PID process will be established for creating, selecting, and executing projects that are profitable. Students working on PID projects practice many of the high impact learning activities such as first-year experiences, common intellectual experiences, learning communities, collaborative assignments and projects, undergraduate research, and capstone projects. Not only will they gain experience from real-world product development, they also make contributions to curriculum enhancement so that many more students received the benefits as well. Many students could be hired to work on PID projects, and students will be positively impacted by PID projects. Three surveys were conducted with positive overall responses. During today's tough economic times, being able to create a high impact learning environment without significant institutional financial support in the long run is a challenge to educators [28]. For students, in particular the ones with financial needs, it is attractive to get paid while learning. There is no universal way to implement HIPs, so to be successful it must be tailored to the specific programs. This paper presents a story of successfulness, which may encourage many universities to do this programme. In addition to the creation of high impact learning environments, PID also could bring other benefits [18].

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