

# **A Qualitative Examination of Learners' Experiences in Experiential BME-In-Practice Modules**

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## **Abstract**

Learners of Biomedical Engineering (BME) programs report difficulties finding relevant jobs post-graduation and also express a disconnect between their training and future professional roles. In addition, because of the interdisciplinary nature of BME, there is a lack of shared understanding of the field between learners, departments, and employers. This lack of understanding further contributes to the disconnect between instruction and practice. To bridge the gap between curricular experiences and learners' understanding of career opportunities in BME, we developed a series of 1-credit (4-week) BME-In-Practice Modules that exposed biomedical learners to biomedical engineering practice. Each 1-credit module in the series was designed to run for four weeks and focused on different areas in BME such as Tissue engineering, Computational Modeling, Medical Device Development, Drug Development, Regulations, and Neural Engineering. Learners enrolled in one or multiple modules and engaged in experiential learning for 4-weeks to gain knowledge and skills relevant to the BME area of focus in the module(s). Following the conclusion of the BME-In-Practice series, we collected survey data from learners who participated in the modules to address the following research questions: 1) What are learners' goals and motivations for enrolling in the BME-In-Practice Module(s)? and 2) How did learners' experiences with the module(s) align with their goals and influence their graduation plans? The survey was administered using Qualtrics and consisted of multiple open-ended questions examining learners' goals and motivations for participating in the BME-in-Practice Module(s) and questions assessing their experiences with the series. Responses to the open-ended survey questions were analyzed using a qualitative interpretive approach. Our results identify different goals related to learners' professional interests and competencies when enrolling in the module. Learners reported gaining practical experiences as well as clarity and direction about their professional futures. We also discuss the graduation plans and outcomes reported by the learners' who participated in the modules, followed by implications for practice and future research.

## **1. Introduction**

Interdisciplinary engineering programs such as Biomedical Engineering (BME) expose learners to multiple disciplinary perspectives and areas of knowledge to address problems in healthcare. Consequently, the broad disciplinary exposure allows for flexibility in careers post-graduation and learners in BME are found to be interested in a variety of post-graduation plans such as engineering, engineering-related, and non-engineering jobs as well as graduate school and medical school. [1]–[3]. As a result of the diversity in learners' plans, variation in BME programs across institutions, and unclear understanding among employers about the skill sets of BME engineers [4], [5], BME learners can have varying perceptions of the field [5], [6]. In fact, BME learners report difficulties identifying with the field as well as finding employment and navigating the job market post-graduation [7], [8]. In an effort to address some of the above concerns of learners, we developed a series of BME-In-Practice modules focused on providing experiential learning experiences to BME learners [9], [10]. Research indicates that teaching practices that actively engage learners in inquiry-based and student-centered approaches lead to

better learning outcomes, especially for interdisciplinary fields such as BME [11]. There is also an increasing recognition of the importance of including more hands-on experiential learning in engineering [12]. Therefore, the purpose of this paper is to understand BME learners' experiences with experiential learning in the BME-In-Practice series. In particular, the following research questions were addressed: 1) What are learners' goals and motivations for enrolling in the BME-In-Practice Module(s)? and 2) How did learners' experiences with the module(s) align with their goals and influence their graduation plans?

## **2. Methods**

### *2.1 Research Context*

Teams of upper level undergraduate students, graduate students, post-docs and faculty engaged in the instructional design process and developed a series of 1-credit BME-In-Practice Modules to expose BME learners' to more experiential learning opportunities and to connect them to biomedical engineering practice. To design the modules, the teams utilized literature on student learning, and curriculum design as well as shadowed and interviewed various BME stakeholders such as engineers, recruiters, and researchers to understand their needs. The instructional design teams were able to identify gaps in the existing curriculum and align content in the modules to needs in the industry and BME careers by engaging in the above design process. Each 1-credit module in the series was designed to run for four weeks and was primarily taught by the graduate instructors who were involved in designing the module. Each module focused on different areas in BME such as Tissue engineering, Computational Modeling, Medical Device Development, Drug Development, Regulations, and Neural Engineering. A list of the modules that were offered is included below:

Building a Tumor, An Introduction to Tissue Engineering  
Engineering the Cellular Microenvironment: An Introduction to Tissue Engineering  
How to (Almost) Make an Organ Using Regenerative Engineering  
Introduction to Computer-Aided Diagnosis  
Introduction to Medical Product Design, Prototyping, and Testing  
Introduction to Neural Engineering and Modeling  
Roadmap to Drug Development  
Wrangling with Regulations: Introduction to Regulatory Science

Learners' enrolled in one or multiple modules and engaged in experiential learning for 4-weeks to gain knowledge and skills relevant to the BME area of focus in the module(s). For example, in the Medical Device Development Modules, students learnt relevant skills such as 3D printing, finite element analysis (FEA), computer aided design (CAD) to prototype, evaluate, and iterate bone plates or a similar open-ended design project with constraints. Similarly, in the Tissue Engineering Modules, students developed laboratory skills such as cell culture, quantitative assays, and imaging through engineering hydrogels for cellular scaffolding.

### *2.2. Data Collection and Analysis*

Following the conclusion of the BME-In-Practice series, we collected survey data from learners who participated in the modules. The survey was administered using Qualtrics and consisted of

the following six open-ended questions: 1) What were your goals (educational, career, or other) when enrolling in the BME-in-Practice Module? 2) Why were you interested in enrolling in the BME-in-Practice Module(s)? 3) Thinking about the actual experience in the BME-in-Practice module, how did that align with your original goals or motivations for enrolling? 4) Comparing the BME-in-Practice module(s) to your other BIOMEDE courses, what was different/similar about them? 5) If you haven't graduated, what are your plans upon graduation? If you have graduated, what are you doing now? and 6) Did the participation in the BME-in-Practice module(s) influence (positively or negatively) that? In what way?

The initial intent of these open-ended survey questions was for formative assessment of learners' experience with the series. Therefore the survey did not include any Likert type questions evaluating participants' learning. The learning outcomes of participants who took part in the modules were previously evaluated using quantitative pre-/post surveys and are published elsewhere [10]. Recognizing the added value of the qualitative data collected, the survey responses reported in this paper in particular examine learners' goals and motivations for participating in the BME-in-Practice Module(s) and assess their experience with the series. In addition to the open-ended questions, we also collected some general information about the learners' such as the number of modules they enrolled in, the name of the module(s), the learners' academic standing when they were enrolled in the module(s) and when they took the survey, and their pronouns.

Responses to the open-ended survey questions were analyzed using a qualitative interpretive approach. The nature of qualitative research is not to generalize but to understand peoples' unique experiences in a given context. Therefore, given the qualitative nature of the survey responses, we hesitate to quantify the responses obtained from the participants. In general, survey responses were grouped into emergent themes when at least three learners indicated a similar experience with the modules

Responses to survey questions one and two above were used to answer the first research question: *what are learners' goals and motivations for enrolling in the BME-In-Practice Module(s)?* Similarly, responses to survey questions three and four were used to answer the second research question: *how did learners' experiences with the module(s) align with their goals and influence their graduation plans?*

### **3. Results**

A total of 23 participants responded to the survey. Of the participants who responded, 74% (n=17) indicated she/her/hers as their pronouns and 26% (n=6) indicated he/him/his as their pronouns. Fifty percent of the participants (n=11) were in their 2<sup>nd</sup> year when enrolled in a module, 36% (n=8) were in their 1<sup>st</sup> year, 9% (n=2) were in their 4<sup>th</sup> year, 5% (n=1) were in their 3<sup>rd</sup> year. Most of the participants enrolled in one (45% n=9) to two (40% n=8) modules with few participants (15% n=3) enrolling in more than two modules.

#### *Goals and Motivations for Enrolling in BME-In-Practice Module(s)*

Analyzing learners' response to questions one and two in the survey revealed emergent themes around their goals and motivations when enrolling in the module(s). The key themes that

emerged from analyzing the responses to these questions include: 1) wanting to enter into the industry and/or a BME career, 2) explore and understand different areas in BME, and 3) gain relevant skills for employment, 4) gain practical experience and exposure, and 5) interest in a low effort, high impact course option. See Table 1.

Table 1.  
Summary of Key Themes from Participants' Responses

| Research Questions   | Key Emergent Themes                              |
|--|--|
| Learners' goals and motivation when enrolling in the BME-In-Practice Module(s) | Enter into the industry and/or a BME career      |
|  | Explore and/or understand different areas in BME |
|  | Gain skills for employment                       |
|  | Gain experience and exposure                     |
| Learner's experience with the modules and alignment with goals                 | Low effort and high impact option                |
|  | Provided clarity and direction                   |
|  | Gain practical experiences and exposure          |
|  | Hands-on   |

A majority of the learners expressed wanting to enter the industry upon graduation, specifically into BME focused areas such as medical product development, biotechnology, biomechanics, medical devices, tissue engineering etc. Similarly, many learners also expressed wanting to understand and explore different areas in BME. Some learners wanted to engage in this exploration to gain clarity on the different concentrations and related pathways in BME while other learners were interested in gaining specific knowledge about a particular module topic. For example, a learner responded that *“my goal at the time was to see what area of BME I wanted to concentrate in and just to get more experience”* and another learner mentioned that they *“wanted to get more exposure to concepts and methods in BME that I wouldn't otherwise get for a few years.”* On the other hand, another learner responded that they *“wanted to better understand the various aspects involved and related to pharmaceuticals and drug discovery/development.”*

Some learners also expressed that their goal when enrolling in the module(s) was to gain hands-on and relevant skills that could also prepare them for industry and practice. For example, one learner responded that *“I wanted to gain skills that would make me more marketable as an underclassman. I also thought these courses would present material I had learned in other classes, in a more easily understood format.”* Other learners also mentioned that *“I wanted skills which would make me more employable”* and that they wanted to *“gain hands-on design skills to strengthen resume/prepare for internships.”* Related to this theme, some learners also felt that enrolling in the modules would help them gain relevant practical experience and exposure in

BME. A learner responded that *“I took the modules with hope that I would get some experience in ANY unique realm of BME that would spark my interest. I felt that my math and science classes gave me almost no insight into what jobs I could have and what I even enjoyed doing.”* For some learners, the motivation to gain some experience was directly related to working in the industry. For example, a learner felt that *“these modules would give me some good experience that would apply directly to working in industry”* while another learner was looking to *“gaining additional, hands-on experience with technical skills that I could leverage to secure an internship.”*

Finally, some learners also mentioned that the modules seemed like an option that were low effort with high impact outcomes. A learner mentioned that *“it was a perfect small course that had not too much work but large benefits and impact”* and another learner responded that *“I wanted to learn about topics that I thought would be beneficial, without taking a full class.”* A learner also pointed out that *“it was a good way to obtain credits for graduation without adding additional workload over classes and research, especially.”*

### *Learners' Experiences with the Module(s)*

Three key themes emerged from analyzing learners' responses to questions three and four. These themes include: 1) gaining clarity and direction, 2) gaining practical experiences and exposure, and 3) hands-on learning. Many of the learners expressed that participation in the modules provided them with clarity about BME. A learner noted that *“I definitely learned more about what a BME major might look like, and what I could be doing if I were to choose the major.”* Similarly, for some the modules also provided direction with regards to their future goals and plans. For example, for one learner, *“It helped a lot. It made me realize I was less interested with working in a wet lab or even medical lab. It also showed me that I was more interested in Mechanical Engineering than anything in the medical field.”* For another learner, *“I felt that the module helped generate an idea of how all these more specific topics evolved and where they belonged.”* Some learners also felt like the modules allowed them to gain clarity on the opportunities and pathways in BME. A learner mentioned that *“I learned so much about the different opportunities out there, grad vs PhD, industry vs SUGGS.”*

Similar to the theme found in responses to questions one and two, learners reported gaining practical experiences and exposure through their participation in the module(s). Some examples given by learners include *“I got a chance to learn cell culture skills (freezing, thawing, counting, splitting, plating, etc.)”*, *“I got to practice CAD modeling, 3D printing, and physical testing”*, *“These courses have also given me a lot of exposure and experience that I have been able to talk about in job interviews, and I think this has really given me an edge, as well as made me more confident in my technical knowledge and qualifications overall.”* Lastly, a number of learners commented that the module(s) were much more hands-on, and application focused compared to their other BME courses. Learners appreciated the project-based and experiential learning experience as indicated in their responses. One learner mentioned *“We focused much more on the “big picture” in the BME-in-Practice modules, rather than the details of specific math or physical calculations. I like that the BME-in-Practice modules were very hands-on, discussion-based, and were in a small classroom setting, rather than a big lecture room.”* Another learner

responded that, “*I liked that [the modules] were smaller, more intimate groups and provided more hands on skills directly relevant to my career.*”

#### **4. Discussion and Conclusion**

We developed a series of BME-In-Practice modules to provide experiential learning opportunities to BME learners. Based on the results from our survey of the participants, the modules appear to provide relevant experiential and authentic learning experience to BME learners’. By engaging in experiential learning through the modules, learners were able to gain clarity and direction with regards to their perception of BME as well as their future goals and career plans. The learners’ report being exposed to relevant practical experiences and areas of knowledge within BME which in turn contributed to an increased understanding of their perception of BME. By engaging in relevant experiences, the learners also gain relevant marketable skills that seem to improve their employability and learners' understanding of their post-graduation options.

Most of the learners enrolled in the modules were interested in entering the industry. However, among the participants there were also a small number of learners interested in attending graduate school who found the modules relevant and helpful. Specifically, the BME-In-Practice modules were appealing to BME learners who were interested in exploring different areas in BME, gaining relevant skills and experiences, and wanted a low effort option. Most learners in the modules noted that the low credit hours and workload associated with the modules motivated them to enroll in the course. This has important implications for course design as learners might be more likely to engage in exploratory and experiential experiences when the associated workload and time away from core coursework is not overly taxing. Finally, the ability to count the credits of the modules towards their curricular requirements also allowed for increased adoption of the coursework by the learners.

The principal investigator who conceived of and implemented the BME-in-Practice modules recently relocated to a different university. As a result, the program as described in its form was paused while the PI was in transition. Given the resultant impact of such experiences on BME learners’ identities and outcomes, we recommend that other BME programs explore ways to incorporate co-created experiential learning opportunities influenced by professional practice into BME curriculum.

#### **Acknowledgements**

Funding for this research was provided by the National Science Foundation NSF-EEC-1825669 grant. The views expressed in this paper are those of the authors and do not necessarily reflect views of the National Science Foundation

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