Board 22: Work in Progress: Promoting and Assessing Curiosity Through A Tissue Engineering Course Project Incorporating Biomimicry

Dr. Wujie Zhang, Milwaukee School of Engineering

Dr. Wujie Zhang is an associate professor of Biomolecular Engineering in the Physics and Chemistry Department at the Milwaukee School of Engineering (MSOE). He received his M.S. and B.S. degrees in Food Science and Engineering from the University of Shanghai for Science and Technology and his Ph.D. degree in Biomedical Engineering from the University of South Carolina. Dr. Zhang's scholarly work and research span biomaterials, tissue engineering, drug delivery, and cancer treatment. With numerous external and internal funding sources, he is actively engaged in research involving undergraduate students in various areas, including engineered red blood cells for oxygen therapeutics development. Dr. Zhang has published more than 40 peer-reviewed journal articles, authored the book Nanotechnology for Bioengineers, and holds multiple patents. When it comes to engineering and chemical sciences education, he is especially interested in integrating the entrepreneurial mindset into a wide range of courses. Dr. Zhang has been recognized by the ASEE's Prism magazine as one of 20 high-achieving researchers and educators under 40 (2018), the Milwaukee Business Journal 40 under 40 (2019), and as one of Wisconsin's 34 Most Influential Asian American Leaders (2021). Dr. Zhang is devotedly involved in the community and currently serves on the City of Milwaukee's Board of Health and as a prior Milwaukee section chair of the America Chemical Society (ACS). He is an advocate for equity and inclusion, and his work in this space was recognized by the MSOE community with the 2020 Diversity and Inclusion Advocate Award.

Lauren M Beverung, Milwaukee School of Engineering
Rebecca McKeown
Tammy J. Rice-Bailey

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Abstract

To better implement the curiosity aspect of entrepreneurial-minded learning (EML), biomimicry was adopted in a tissue engineering course project to nourish curiosity. Biomimicry belongs to bioinspired design and has been reported to offer educators a way to engage students with systems thinking and creative problem-solving, which can potentially inspire student curiosity. Students were required to use natural materials (from plants, insects, etc.) and natural structures/mechanisms in tissue-engineered product design to adopt the biomimicry principle. At the end of the project, an anonymous survey was conducted to assess the relationship between student curiosity and project experience. The curiosity-related assessment was based on the five-dimensional curiosity scale including Joyous Exploration, Stress Tolerance, and Thrill Seeking. Contrary to hypotheses, students' reported project experience did not relate much to their overall curiosity. However, students' reported interest in the project was positively related to their desire to problem-solve (Deprivation Sensitivity) and negatively related to their Social Curiosity. Additional assessments will be conducted in the future to validate and expand upon the findings.

Introduction

The goal of entrepreneurially minded learning (EML) is to go beyond delivering entrepreneurship knowledge and skills to students by providing them with opportunities to approach engineering problems and challenges in a more entrepreneurial way [1]. EML has been transforming U.S. engineering education. According to KEEN, one of the leading players in promoting EML in engineering education, there are three key elements: curiosity, connections, and creating value (i.e., 3C's) [2]. The connection and creating values aspects of EML can be easily addressed through course projects. However, equipping students with a spirit of curiosity has been challenging, especially considering the complexity and variability of curiosity [3]. Although it can be suppressed by the education system, curiosity can be taught and promoted [3].

To better implement the curiosity aspect, biomimicry was adopted as it cultivates curiosity [4]. The study of biomimicry design thinking education is an emerging field [5]. Biomimicry is a type of bio-inspired design and is defined by Janine M. Benyus as imitating or taking inspiration from nature's forms, processes, and ecosystems to solve problems for humans [4, 6]. The Five-Dimensional Curiosity Scale (5DC) was used for curiosity assessment which comprises 25 items that can be categorized into five dimensions: joyous exploration, deprivation sensitivity, social tolerance, social curiosity, and thrill-seeking [6, 7].

Methods

Students Selection

All the students who registered for the tissue engineering course (EB-3810) were eligible to participate in the project. The course is mostly taken by the Biomolecular Engineering juniors and seniors as a technical elective. Approximately 10-15 students enroll in this course each year.

Students are expected to have taken Cell Biology and Genetics, Biochemistry, and Transport Phenomena courses considering their standings. No other selection criterion was applied.

Incorporation of Biomimicry

Half a lecture time was used to introduce the basics of biomimicry. Considering it has been challenging for students to incorporate biomimicry during ideation (about half the students considered it somewhat difficult based on an internal course suvery), related handouts were provided to students including examples of the application of biomimicry in tissue-engineered product design. One of the examples was the fabrication of vascularized tissues using the plant leaf venation system as the fluid transport in leaf venation obeys the same Murry's Law as the blood vasculature in animals [8].

Project Activities and Timelines

The project activities and related timelines are summarized in Appendix I. The project was introduced and project teams formed (groups of 4; students formed their own teams) during the first lecture of the course. Project descriptions and rubrics were provided at the same time. Students were expected to work on the project throughout the quarter. There were two submittals: project ideation and final project report. Students were given the opportunity to validate their project idea (e.g., through customer interviews) and perform the prototyping during the last two weeks (optional). To help students validate their project ideas, a lecture video on Lean LaunchPad, customer discovery and value proposition determination was produced. The video provided the students with the necessary tools to validate their ideas and associated value propositions. In addition, students were expected to investigate the current products in market/under development (e.g., shortcomings) while considering the constraints.

Curiosity Research Procedure

A voluntary Qualtrics survey was used to assess students' curiosity. The first part of the survey included the 25 items of the 5DC without modifications [7]. And the second part of the survey consisted of specific questions designed to detemine whether the project promotes student curiosity and their overall project experience.The questions and response options are shown in the Appendix II. The anonymous survey containing an informed consent statement was sent to students through their Milwaukee School of Engineering (MSOE) issued e-mail accounts at week 9. Students were given until the final exams week (week 11) to complete the survey on their own time. Safeguards were put in place to make surveys nonidentifiable. The MSOE's Institutional Review Board (IRB) has determined this project is exempted from IRB full board review according to federal regulations.

Results and Discussions

This was an exploratory/pilot study to gain a sense of students' feelings about a course project using biomimicry as it relates to their curiosity. Twelve students enrolled in the course. Three out of the four groups conducted some form of customer discovery/idea validation such as survey and customer interview. Seven out of the twelve students (58.3 %) completed the Qualtrics

survey. Means and standard deviations for students' feelings about the project are provided in Figure 1 of Appendix III. Students agreed that the project introduced them to new concepts they might further investigate in the future. Additionally, most students felt the project was exciting and interesting. Overall, students were not too stressed by the project and felt is was not too difficult or easy. The project was deemed interesting and exciting regardless of students' personal sense of curiosity. In their qualitative responses, students mentioned their excitement regarding "being able to explore different examples of biomimicry and being challenged to consider how that could be incorporated into our designs" and "learning just what can be done with the technologies that are available." This relates to students' statements about interest in the project. One student's responses sums up the general consensus that students felt "The most interesting part of the project was seeing all the different ways tissue engineering can be beneficial to the world and seeing how biomimicry really can be used in designs for tissue engineering." Other students' reported it was interesting to "[delve] in to how animal, plant, or bacteria systems may be applied to solve human problems" and "[learn] different applications of tissue engineering, and how the field is stretching what can be done with regards to the human body." Thus, regardless of personal curiosity factors, the project generated a sense of enthusiasm in students.

Figure 2 in Appendix III displays the means and standard deviations for the 5DC scores. Students tended to have higher scores for Joyous Exploration compared to the other categories. The lowest scores, on average, were for Thrill Seeking. To explore how students' curiosity related to their impressions of the project, we conducted a Spearman's rho correlation analysis. The analysis revealed three notable relationships. First, level of interest in the project had a strong, positive relationship with scores for Deprivation Sensitivity, $r(5) = 0.798$, $p = 0.032$ and a strong, negative relationship with scores for Social Curiosity, $r(5) = -0.791$, $p = 0.034$. Additionally, there was a strong, but non-significant, positive relationship between level of excitement for the project and Deprivation Sensitivity, $r(5) = 0.724$, $p = 0.066$. This analysis indicated that students who strongly agreed the project was interesting had higher scores in Deprivation Sensitivity (the need to resolve a lack of information) and lower scores in Social Curiosity (interest in the lives of others) [7].

Future Directions

Overall, our pilot study revealed that students' feelings about the project were largely separate from their personal sense of curiosity. This can be interpreted as a strength of the course project, as we would hope the project arouses all students' curiosity. More data is needed to determine if this hypothesis is true. This project will be continued in the EIB-3100 course (Cell Culture and Tissue Engineering). Different approaches for assigning groups will be investigated to see their effects on curiosity. Moreover, the baseline (students conduct a similar project but without biomimicry incorporation) will be set for more accurate assessments. The motivation survey questionnaire will be modified by collaborating with experts in the field, especiailly including the evaluation of the effects of group assignment, project novelty, and hands-on experience on curiosity. The correlation between students' engagement/curiosity survey results and actual performance will also be explored. The feedback will be used to improve the course and implement similar projects in other courses.

References

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Appendices

Appendix I. Summary of project activities and related timelines.

Activity	Submittal(s)	Timeline
Introduction and team formation		Week 1
Project ideation (incorporation of biomimicry)	Project idea description including the major reference article(s))	Weeks 1-4
Project idea validation (optional)	Interview notes, survey, etc.	Weeks 4-10
Prototyping planning (optional)	Prototyping plan	Weeks 4-8
Prototyping (optional)	Prototype and a short video recording of the whole process	Weeks 9-10
Project report writing	Final project report	Weeks 1-10

Appendix II. Survey questions & response options

1. Did this project introduce you to any new concepts you might further investigate at another time?

   Response options: 5-strongly agree; 4-agree; 3-neutral; 2-disagree; 1-strongly disagree
2. Please rate your experience of the process of incorporating biomimicry into tissue engineering on the following scales:
   a. 5-very exciting, 4-exciting, 3-neutral, 2-not too exciting, 1-not exciting at all
   b. 5-very interesting, 4-interesting, 3-neutral, 2-not too interesting, 1-not interesting at all
   c. 5-very stressful, 4-stressful, 3-neutral, 2-not too stressful, 1-not stressful at all
   d. 5-very difficult, 4-difficult, 3-neutral, 2-not too difficult, 1-not difficult at all
3. If underlined options were selected, the following qualitative questions appeared, respectively
   a. What was the most exciting aspect of this project?
   b. What was the most interesting aspect of this project?
   c. What was the most stressful aspect of this project?
   d. What was the most difficult aspect of this project?

Appendix III. Results of the pilot study

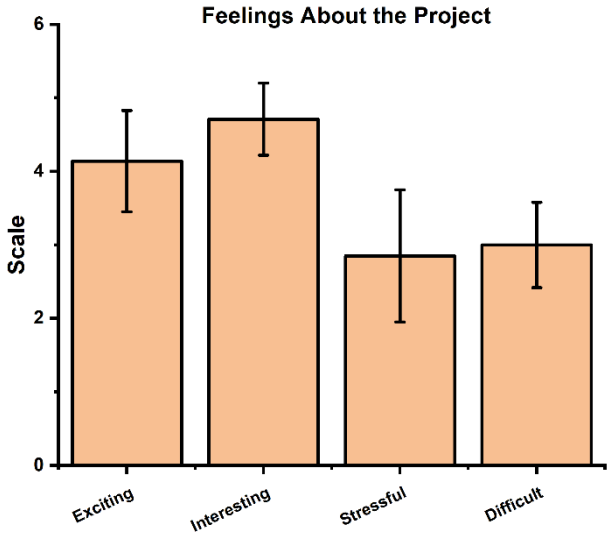

Figure 1. Scores of students' feelings about the project. A 5-point sacle was used from 'very' (5) to 'not at all' (1). Results are displayed as the mean ± SD.

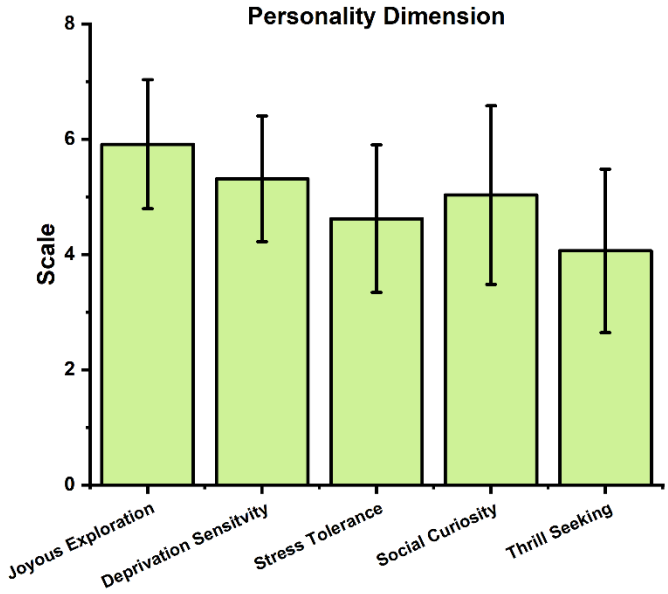

Figure 2. Students' 5DC scores. A 7-point sacle was used from 'completely describes me' (7) to 'does not describe me at all' (1). Results are displayed as the mean ± SD.