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The Fifth Element of Biomedical Engineering is Innovation: A Quintessential Design Studio Course Focusing on the ”Wearable Technology” Ecosystem

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Tags: Biomedical Engineering, Wearable Technology, Entrepreneurial Mindset, Innovation

Abstract

Engineering has played a pivotal role in industrial revolutions, lifestyle transformations and accelerated changes in our society. The “4th Industrial Revolution” is blurring the boundaries between the physical and digital worlds with technology moving from large/stationary systems controlled by keyboards to light wearable (or implanted) devices that allow for new ways of interacting with information. To keep pace with these advancements, biomedical engineering education is shifting towards theory-practice necessities of engineering professions, inclusion of “real-world” problems that respond to society’s needs and greater exposure to digital models, fabrication and programming. To this we emphasize “Innovation” as a quintessential mindset that distinguishes engineers who discover opportunities, draw from multi-disciplinary capabilities to create solutions and create real world value. To advance this mindset in biomedical engineering curricula, we provide a concrete case study of a course designed to emphasize this mindset which may be replicated.

"BME 3113: Wearable Technology Design Studio" combines physiology, embedded engineering and industrial design topics to address innovations within the Wearable Technology ecosystem. Using student-centered pedagogical approaches, the course integrates maker movement principles while fulfilling engineering curriculum requirements, guiding students through model creation, prototyping, and business plan development. The studio format enhances collaboration and innovation to enable students to develop confidence in working with various types of sensors that are the backbone of many wearable devices. In the context of a biomedical engineering program, students are encouraged to create consumer product applications focused on wellness, which may overlap with similar, but highly regulated medical devices.

Offered since 2017, the course has impacted approximately 120 students. The course takes place during a 3-hour studio block which consists of lectures, individual skill-building activities, and group project work. Assessment of learning outcomes for accreditation, student feedback, and instructors' reflections are presented. The course's iterative history, curricular benefits, and best practices for implementation are discussed. Commentary on syllabi, outcomes, logistics, COVID-19 adaptations, and online resources provides insights for programs interested in replicating this innovative approach to biomedical engineering education.

1. Background and Motivation

Technological innovation by humans has accelerated and eclipsed the evolutionary process of biological innovation which has existed on earth for billions of years (Figure 1). Modern human behavior, marked by social learning, abstract thinking, and complex communication, enabled the rapid accumulation and transmission of innovations across generations. The development of mass communication evolved from tribal conversations to written language and eventually to today's digital technologies, fundamentally changing how information and innovation spreads. According to the World Economic Forum, three major Industrial Revolutions (steam, electricity, and digital electronics) have transformed society over the past 350 years, leading to our current "Industry 4.0" era where cyber-physical systems blur the boundaries between physical, digital, and biological domains [1]. Even more recently, the breakneck developments in generative artificial intelligence have accelerated adoption and predictions about when artificial general intelligence (AGI) will be achieved and potentially reach superhuman levels. The field of biomedical engineering provides a unique perspective into the overlaps between the historical design processes of biology and industrial design.

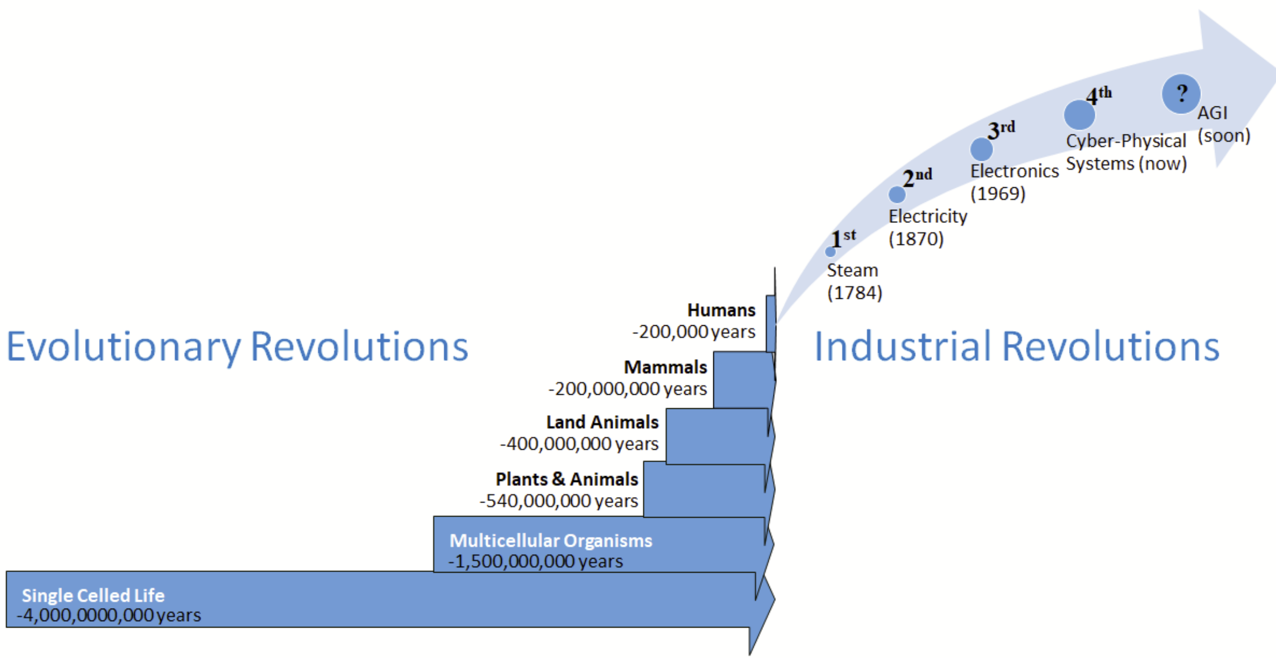

Figure 1. A brief timeline of the history of Earth.

Engineering has played a pivotal role in technology-driven industrial revolutions, lifestyle transformations and accelerated changes in our society [2]. Wearable technology devices have flourished recently due to technological advancements, rapidly expanding entrepreneurial activity and consumer interest [3]. Wearable technology companies and individuals create new products for fashion, sports, lifestyle, computing and health industries. Devices like the Apple Watch, Fitbit, and virtual/augmented reality devices like the Apple Vision Pro or Ray-Ban Meta Smart Glasses are well known and have attracted much consumer and investor interest. These consumer technologies can help motivate and provide a real-world perspective to educational experiences [4]. Engineering students rarely experience the constraints and concerns of product development at any point in a traditional curriculum, even though engineers are often the developers of these products [5].

The subject of wearable technology is also of particular interest in Biomedical Engineering (BME) due to the similarities and differences between highly regulated medical devices and consumer-focused wearables. When BME students study medical device design in their degree programs they are instructed in the entire lifecycle of device development, from initial concept and needs assessment through regulatory compliance and commercialization. Such courses combine technical aspects like materials selection and manufacturing processes with crucial regulatory requirements, safety protocols, and testing methodologies. The traditional pedagogical approach in engineering builds a strong foundation in math and sciences along with laboratory coursework that demonstrates these principles through representative theoretical and experimental models. Students learn deductively and appreciate the careful caution exhibited by a developer in ascertaining that the solution is reliable and accurate. Although the learn-implement-build-test technique is necessary for communicating large amounts of technical information, it lacks the real-world relevance and use of available resources necessary for product design. Furthermore, technical competence is not enough to address the practical considerations of successful product design [6].

Engineering education has emphasized STEM curriculum, laboratory experience, design projects, and professional skills in accordance with guidelines for accreditation [7]. Traditionally focused on theoretical and scientific knowledge, these curriculum and coursework may lack important student learning opportunities [8]. Proposed teaching methods include rebalancing towards theory-practice necessities, inclusion of "real-world" problems, and greater exposure to digital technologies, including; sensors/electronics, models for simulation/analysis, computer aided design/fabrication, and programming [9]. Inductive pedagogies like Active Collaborative Learning (ACL), Project Based Learning (PBL) [10], and Entrepreneurial Minded Learning (EML) are more student-centered and begin with a real-world problem or an observation that is introduced to the students [11]. These techniques can lead to deeper student learning when properly implemented [12]. Engineering education leaders have called for curriculum reform that provides students with repeated design-implement experiences as a more authentic context for learning fundamental science content, engineering principles and analytical capabilities [13]. The aim is to develop students who are better at adapting to new trends, embracing creativity and leadership, understanding engineering impacts on society and business, as well as providing more opportunities to experience engineering design [14]. Inductive pedagogy also aligns with the goals of the Entrepreneurial Mindset framework [15], which says that students should be supported so that they can "create value, gather and assimilate information to discover opportunities or insights for further action." We embraced these pedagogies to create a project-based course that requires deep immersion into a real world, exciting and accessible topic to allow students the opportunity to build confidence with their entrepreneurship skills (Curiosity). The multi-disciplinary instruction expands the students' capabilities to create solutions across a broad variety of real-world opportunities (Connections). Students are expected to seek out customer needs and deliver solutions that address the social, economic and environmental impacts (Creating Value).

Studio courses are common in the College of Architecture and Design at Lawrence Technological University, but have been recommended for integration into other academic fields, including engineering [16]. Studio courses typically integrate content delivery, hands-on activity, and discussion into one scheduled class period held in a single room [17]. The studio instruction space is flexible to enhance collaboration and innovation [18]. Lecturing is limited while experiential learning and the production of "real world" artifacts using a structured design process are emphasized. Studio courses require more contact time than traditional engineering courses, the number of students per section is typically limited to less than 30 students and "team-teaching" by two or more faculty is seen as beneficial. Frequently, these courses designate a relevant design theme that allows the students to identify shared opportunities and encourage student ownership. Finally, such courses often celebrate accomplishments at the end of the studio experience with an exposition that includes faculty and industrial representatives. The studio course format utilizes inductive pedagogy and experiential learning [19] and follows a design-build-test-reflect technique and develops many of the characteristics of the maker movement [20].

The maker movement is a cultural phenomenon that encourages people to become creators and producers rather than just consumers. It has opened the door for hobbyists, inventors and hackers to turn concepts into products by focusing on technology gaps and customer needs through rapid prototyping. The end products demonstrate the entrepreneurial spirit and on-demand learning through repeated trials and failures. Technology companies are playing their part in supporting this interest by developing new hardware and software development kits that reduce the time and expenses required to apply this technology in new and creative ways. The open hardware and plug-in sensors are portable, easily configurable and can be cascaded for more complex measurement schemes. In addition, there are many cost-effective sensor kits with modules to measure a variety of environmental and physiological parameters, which are now available on the market (Figure 2). Many kits also come with instructional manuals and examples that make it easy for novices or non-technical users to learn and to build functional devices quickly. The use of open-source electronic prototyping platforms can allow students to create interactive electronic devices that do not require extensive backgrounds in electronics, sensors and software design.

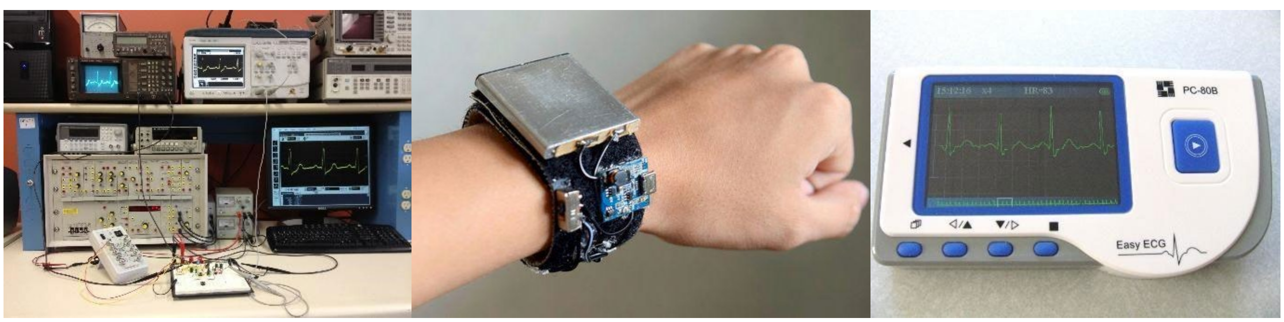

Figure 2. Three implementations of an Electrocardiogram (ECG) device; (Left) breadboard, (Middle) wearable, and (Right) medical.

The goal of this project was to develop a design studio course focused on real world themes and practical skills for technology consumer devices. Our approach combines Physiology, Embedded Engineering, and Industrial Design to address innovations within the Wearable Technology ecosystem. Scientific methods for measuring activities, responses, and outcomes are applied to creating physical computing systems [21] with design validation and usability verification [22]. While this course was primarily intended for BME students, the pre-requisite requirements were minimized to allow other students, including non-engineers, to register. Similar course structures and topics could be applied in many disciplines such as; Mechanical, Electrical and Robotics Engineering, Computer Science, Information Technology, and Product Design.

2. Design Studio Course Structure

The introduction of this course aimed to expand opportunities for engineering undergraduate students to practice engineering design and implementation, beyond the required cornerstone and capstone design courses. At Lawrence Technological University, the College of Engineering worked closely with the Kern Entrepreneurial Engineering Network (KEEN) to develop a strategy to transform the four year curriculum in a way that promotes the entrepreneurial mindset of students. This effort created new multi-disciplinary freshman (EGE 1001) and sophomore (EGE 2123) courses and identified the need for discipline-specific junior courses to round out this sequence before students begin their senior projects [23]. The areas of focus for the junior level experience were; practice engineering tools, project-based delivery, discipline specific techniques and content, and identify capstone opportunities.

This Wearable Technology Design Studio course (BME 3113) in the Biomedical Engineering program adopts wearable technology as a theme to motivate academic topics and give students an opportunity to develop a mindset that fosters creativity and collaboration. This theme is closely related to the Quantified-Self (QS) theme that has been used in previously implemented work to develop and dissemination of EML modules in various engineering and science courses [24]. The Wearable Technology Design Studio course uses maker-friendly pedagogy to introduce students to the concepts and fundamental techniques that are relevant to product design of wearables, including; open electronics microcontrollers, switches, sensors/actuators, displays, LEDs, wireless communication, and programming. The class has minimal prerequisite programming or electronics knowledge. By incorporating aspects of the maker movement, the course allows students to make preliminary models, create prototypes, find limitations and develop business plans with targeted markets around the novelty in a new product.

A novel studio format product design course was developed, featuring hands-on skill-building modules and group projects focused on wearable technology. The studio format uses inductive rather than deductive pedagogy which follows a design-build-test-reflect building around a theme of product development for wearable technology. This studio-based approach, adapted from architecture and industrial design programs, emphasized experiential learning and real-world artifact production in a flexible, collaborative space with extended contact hours, team teaching, and smaller class sizes, culminating in a final exposition of student work. Below is the course schedule from the 2024 course syllabus (Table 1. Included in Appendix - D):

Table 1. Semester schedule of topics, assignments, project goals and deliverables.

Week	Dates	Topics	Individual Assignments	Group Project	Project Deliverables
1	8/27	What is Wearable Tech?	Teardown Wearable Profile	Project 1: "Light-up Costume"	Ideation, Design Sketch, LoFi Prototype
2	9/3	Textiles	Hand Stitching Sewing Machine	Textile Design	Textile Prototype
3	9/10	Circuits and Electronics	TinkerCAD Circuits Blue Devil Boards	LED/Battery Design	LED Prototype
4	*9/17*	*NO CLASS*			
5	9/24	3D Design/ Printing	TinkerCAD + Mechanisms	"Case" Design	Instructable
6	10/8	Microcontrollers + Sensors/Actuators	Adafruit Bluefruit	Project 2: "Mixed Reality Tracker"	**P1 Presentation**
7	10/15	Peripherals + Communication	Bluetooth	Programming Prototype	Design Concept / Code
8	10/22	User Interaction / HCD	Accessibility Design	Usability/UX Design	UX Design
9	10/29	Industrial Design and Ergonomics	Ergonomics	"Fit and Finish" Design	Industrial Design
10	10/24	Tech Revolutions	Extended Reality	Project 3: "Wearable Assistant"	**P2 Presentation**
11	10/31	Machine Learning	PyTorch	Algorithm Design	Algorithm Design
12	11/5	Big Data	Data Visualization	Data Engineering	Data Display
13	11/12	Software	Adobe XD	App Design	App Design
14	11/19	Privacy and Security	Fair Information Practices	Sustainability	Privacy Policy
15	11/26	Product Development	Manufacturing	Hardware Design	Hardware Design
16	12/3	Entrepreneurship	Business Model	Commercialization	"Kickstarter" page
17	12/10	Final			**P3 Presentation**

The course takes place during a 3-hour studio block which consists of lectures, individual skill-building activities, and group project work. The studio format includes a combination of interactive demonstration sessions and group project work. Lecture topics include textiles, 3D printing, circuits, sensors, human-centered design, machine learning, and entrepreneurship. Skill-building activities cover sewing, soldering, electronics, programming, digital fabrication, user interaction, industrial design, app design, data visualization, privacy and security, and business model development. Three group projects are completed: a light-up costume, an orientation tracker for mixed reality, and a "Disruptive Technology" product incorporating AI (see Appendices G through I). Wherever possible, the students use open hardware and software instead of using proprietary components with an emphasis on “maker”-style resources for prototyping.

Students use varying skills and methods of opportunity recognition throughout the sequence of three projects to complete increasing complex wearable technology products. The final project includes the topics of user interaction, artificial intelligence, wireless connection to a mobile device, mobile app development, materials and manufacturability, funding, marketing and differentiation from competing products. Direct and indirect assessments have been developed to analyze the modules and projects. The emphasis for the final project is not to produce a functional device, but on developing a product concept that customers would want to buy, wear, and use. Following the course semester some of the engineers taking this elective may choose to continue with their product idea for their senior Capstone Project, giving them an opportunity to further develop the engineering design and build a functioning device. Student groups are also encouraged to enter the campus business incubator programs to further develop the commercialization prospects of their design concepts.

This course requires significant preparation on the level of a lab course. The acquisition and maintenance of various minor equipment needs to be facilitated. For example, this course requires access to 3D printers, soldering irons, sewing machines, and various hand tools. There are also consumables which need to be purchased before the beginning of the term for each of the hands-on skill-building activities, some of which are reusable between terms. For example, traditional sewing consumables (fabric, thread sets, elastic bands, buttons, snaps, zippers, needles, sewing hoops, velcro, etc.), conductive textiles (conductive thread, conductive fabric, conductive velcro, Velostat, conductive tape, etc.), PLA filament, Adafruit Circuit Playground Bluefruit boards, Arduino Uno boards, resistors, capacitors, LEDs, wires, and custom printed “Blue Devil Boards” for soldering practice were all regularly purchased before the beginning of the fall semester.

This course also requires a dedicated lab/studio space where the various equipment, consumables and student prototypes can be housed and maintained. The lab/studio space must also be made available for “Studio Hours” where instructors and/or student assistants can be available to assist students. Activities and collaborative student work done in this course has required large table tops with adequate access to power outlets as well as basic safety equipment such as first aid kits and fire extinguishers.

3. Assessment

Offered since 2017, the course has impacted approximately 120 students. The most recent course offering was during the fall semester of 2024 (see Appendix D). Direct assessment of student artifacts including prototypes, reports, and final presentations were completed to determine if the students addressed the engineering design steps and reached the expected level of attainment of course content. After a curriculum modification in 2018, the course was included in ABET accreditation reporting for four of the subsequent course offerings. The key performance indicators (KPIs) were assessed using an "Excellent, Adequate, Minimal, Unsatisfactory" (EAMU) vector (Table 2). The description and nominal measurement ranges for each level are set as appropriate to the task associated with the KPI.

Table 2. KPI assessment results for BME 3113.

KPI	Semester	E	A	M	U	Avg
i-1 (L3): Collect relevant technical information, data, and ideas from multiple sources.	F2018	7	9	0	0	2.4
2-b (L4): Examine realistic constraints related to the proposed solution	F2019	12	2	0	0	2.9
3-a (L3) Construct and deliver a logical and articulate communication based on independent work	F2020	8	3	0	0	2.7
c-1 (L3): Use the engineering design process to generate potential solutions to a biomedical need	F2022	7	6	1	0	2.4

Indirect assessment of the students by means of confidential individual and group assessment surveys have also been completed during each of the course offerings (Figure 3). Some comments from student surveys are shown:

- "He (the instructor) didn't know a lot of the material but he was good at finding people who did." (F2017)
- "It was helpful to have everything in steps. So learning how to sew first, then electronics, then sewable electronics." (F2017)
- "I thought that the help from the Graduate students was very beneficial and I appreciated their flexibility to help me outside of class many times." (F2018)
- "Sometimes it seemed like he (the instructor) was learning right along with us, which is not necessarily a bad thing... but that is how it was." (F2018)
- "This course allowed us to explore human interaction with technology on a real world basis which was very interesting to see from the engineers point of view." (F2019)
- "I liked this course and learning a variety of skills!" (F2021)
- "I like the course a lot because it had a lot of hands on aspects. I personally was not a fan of the final project, because it took up the last 6 weeks of the course and we did not get to do as much hands on things. I enjoyed the first 9 weeks and learning how to do new things in engineering fields." (F2023)

- ❖ "I think this course is well structured. I like being able to learn and practice the skills first before having to apply them to our projects." (F2024)

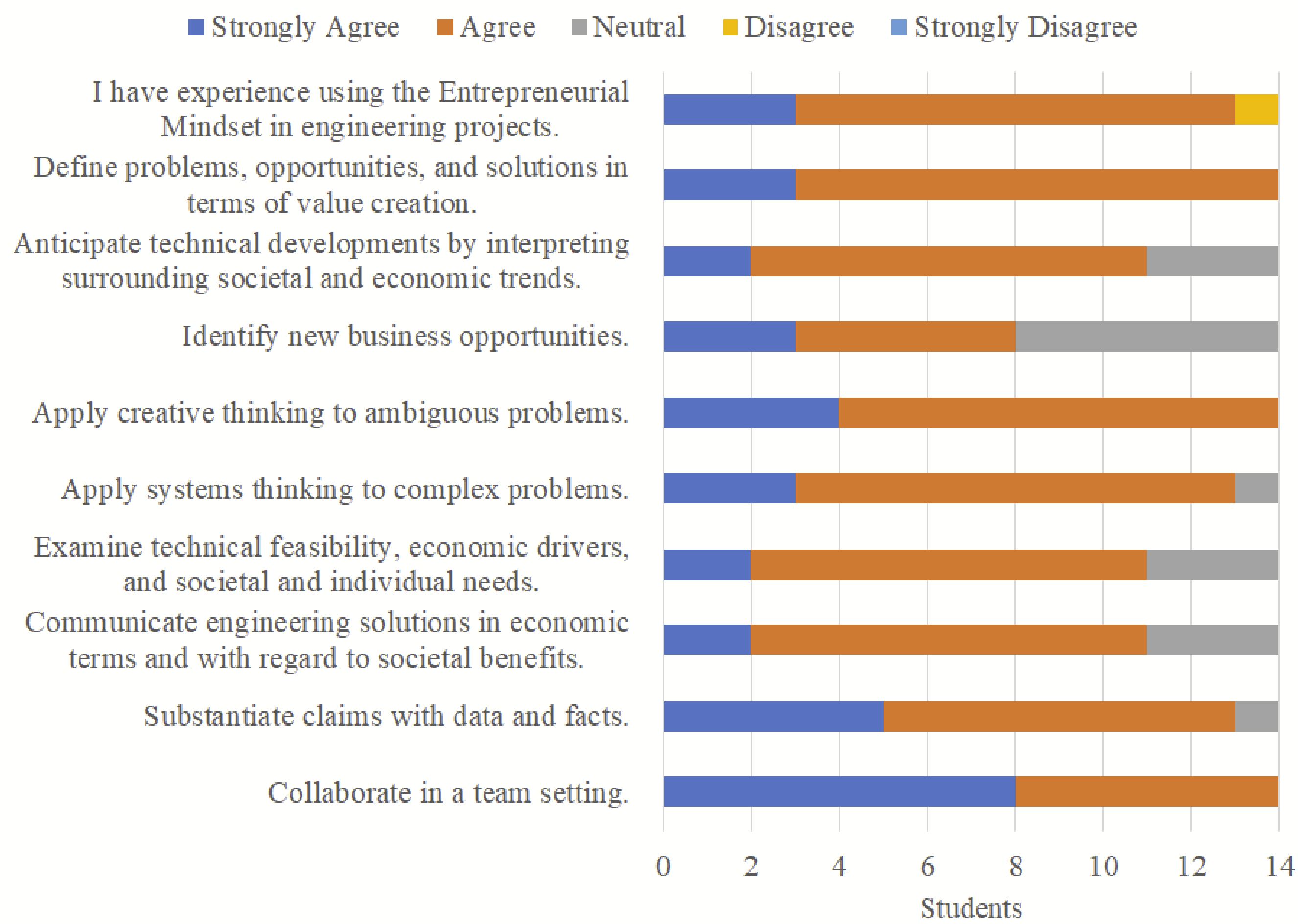

Figure 3. End of semester (F2024) indirect assessment student survey responses to their experiences with using Entrepreneurial Mindset in engineering design projects.

4. Course Design Evolution

The evolution of the Wearable Technology Studio course from 2017 to 2024 offers valuable insights into the development of project-based engineering education. As seen in the syllabi from across this period (Appendices A through D) clear patterns of both consistency and innovation emerge, demonstrating how engineering education can adapt to rapid technological change while maintaining pedagogical effectiveness.

This course was initially developed to be an elective for students in the undergraduate Biomedical Engineering program in response to exit interviews where students cited hands-on experience as the most constructive aspect of their BME education, but described the need for more hands-on experiences. Specifically, they asked to see more courses in certain areas such as; biology/physiology, design/fabrication, electronics and programming. This course was designed to close that gap by offering students opportunities to utilize engineering tools and skills such as electronics, programming, computer-aided design (CAD), machining, and fabrication in order to create wearable device prototypes through team based projects. Initially, collaborating faculty from other colleges taught various modules and also assisted with the communication of ideas in relation to societal and economic benefits and facilitated the wide-ranging and multidisciplinary nature of the course (see Acknowledgements). Special emphasis was made to promote engineering student interactions with product design and business innovation collaborators.

Significant changes have been made in the course's structure and content. The more rigid format specified for how the studio time block was divided in 2017 has evolved into a more flexible structure that better accommodates diverse learning activities. Project focus has shifted to reflect technological advances and societal needs, from general wearable prototypes in 2017 to specialized projects like "Emotive Mask" during the pandemic era, and most recently, "Wearable Assistant" projects incorporating trends in the deployment of artificial intelligence. Technical skill development has expanded considerably, with recent iterations incorporating advanced topics such as machine learning, big data, and extended reality, alongside sophisticated software tools like PyTorch and Adobe XD. The course no longer incorporates outside collaborators teaching various modules. Such modules were replaced by shorter lectures emphasizing the main concepts and allowing for more time to be devoted to individual skill-building exercises and group project work time.

The course has adapted to changing educational environments through increased integration with digital learning platforms, particularly for project documentation and skill portfolio submissions. Industry alignment has strengthened, evolving from only a final report in the form of a mock "Kickstarter" page to comprehensive documentation requirements including “instructables” guides, user manuals, privacy policies, and hardware specifications. This evolution reflects a deeper understanding of industry needs and professional practice requirements. These adaptations also facilitated larger short-term changes necessary in the face of restrictions due to the COVID-19 pandemic. An increased focus on the quality and depth of market analysis as a key driver of design decisions was implemented as part of the project requirements with restricted access to lab work time.

The course has also maintained several foundational elements throughout its iterations. Project-based learning has remained the core pedagogical approach, with all versions emphasizing "learning by doing" through three major group projects complemented by individual skill-building activities. The interdisciplinary nature of the course has persisted through 2024, reflecting the multifaceted nature of wearable technology development. The assessment framework has also remained relatively stable, consistently balancing individual skill development with group project work and final deliverables.

5. Instructor Reflections and Conclusions

During the eight annual implementations of this course, there were many changes, adaptation and improvements by the instructors described in this paper. While the course has continued to be “team-taught", the lead instructors and additional topical experts (see Acknowledgements) were updated from year to year. This diverse input of perspective and experiences has improved the course content, but also created challenges to cut some topics, skills or projects that no longer fit into the course organization. The co-teaching aspect of this model is both crucial to effective implementation of such a course. Effective preparation for this course requires significant time commitment, equipment troubleshooting, and consumables management and is quite difficult when done by a single instructor (even if said instructor has previously co-taught the course). The most effective implementations of this course also included at least one student assistant. When offered at the junior and senior level, this student assistant is best selected from senior-level students who had taken the class previously as juniors. Co-teaching this type of studio format course is also very rewarding for the instructors. Instructors have the opportunity to share their unique expertise with students and each other as they may have both convergent and divergent opinions on the trends within the subject matter and even the design choices of the students.

The iterative history shows evolution of the skills demonstrated and the projects' ideation and topics to improve the course flow, student learning and perceptions. Updating the materials was also a way to keep assignments fresh and up to date with real world trends. Assessment at the program level documents the curricular benefits, which also can be modified due to changes elsewhere in the program. The instructors have noted many best practices for the implementation of skill activities and projects. These should be adapted for other programs to implement a similar course design without losing the quintessential properties that were described.

COVID-19 adaptations were made to limit human contact, while maintaining the skill building activities and discussions. The access to cheap and easily accessible electronics kits and other materials, as well as free online software and Zoom meetings helped to transition the course partially online as needed by the pandemic restrictions. Technology trends, such as software/electronics updates and recent breakthroughs in generative AI have also impacted the course content. A dynamic subject such as Wearable Technology makes it indispensable for instructors to stay up-to-date with these trends and examples from the latest industry product developments. The syllabi in the Appendix show these changes for the evolution of the semester schedules. Additionally, the online resources provided include the original 2017 course projects' assignments as well as the more recent, skill modules and projects' assignments and instructor guides (examples shown in Appendix). This documentation may provide insights for programs interested in replicating this course's innovative approach to biomedical engineering education.

When introducing competing definitions of Wearable Technology during the first week of the course, we suggest that students think of this course as a sister course to the Medical Device Design course offering. There are common skills to the design of Medical Devices and Wearable Technology consumer products. There is also a distinct, yet complementary, mindset involved in their development. This course offers the same distinct, yet complementary, role in the biomedical engineering curriculum at LTU. The BME curricula at LTU has benefited from more than a decade of interest and experimentation in active learning modules ranging from short one to three minute activities to week-long projects, whole courses that embed these pedagogical approaches and even the College of Engineering's revision to a four-year sequence of design courses.The three project design and studio format oriented around skill-building and project work has been very effective at organizing the many topics which are natural to include in such a course. This course design has also been successfully adapted in the creation of an Additive Manufacturing elective course which is co-taught by one of the authors. Engineering curricula benefit from such flexible models as students may be increasingly interested in opportunities to differentiate themselves with more subdiscipline-specific experiences. We believe there are many more opportunities to expose students to emerging technologies and industry trends using this course design.

The word “quintessence” is derived from the Latin “quinta essentia” meaning “fifth element”. Medieval alchemists believed that such a “fifth element” was possible to produce by a series of careful distillations [25]. Quintessence in the context of design is a property of an optimized or “unimprovable” fixed point after many iterations [26]. A quintessential design is one which evolves to occupy a functional niche over the course of many iterations by achieving a balance between many objectives and constraints.

We emphasize "Innovation" as a quintessential mindset that distinguishes engineers who discover opportunities, draw from multi-disciplinary capabilities, and create real-world value [27]. This course fills an innovation gap in the four-year sequence of engineering design courses at LTU. The maintenance of core project-based learning principles while adapting to technological advances and industry needs demonstrates an effective model for engineering education development. The studio format is an effective vehicle for including inductive learning pedagogies into engineering design courses as well as giving students experiences with various skill building activities and EML. The course's evolution into a “quintessential design” suggests that successful engineering design education benefits from maintaining strong foundational elements while systematically incorporating new technologies and methodologies. This approach provides valuable insights for other institutions developing similar courses in rapidly evolving technical fields, illustrating how engineering education can remain relevant and effective while preparing students for emerging technological challenges.

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APPENDIX - A

BME 4903 "Wearable Technology Studio" Syllabus (Fall 2017)

Instructors:	Dr. Mansoor Nasir J337, Biomedical Engineering mnasir@ltu.edu	Dr. Eric G. Meyer E106b, Biomedical Engineering emeyer@ltu.edu
Contributors:	Bryce Evans Game Art bevans@ltu.edu	Dan Shargel Humanities dshargel@ltu.edu
	Justin Ku Management cku@ltu.edu	Franco Delogu Psychology fdelogu@ltu.edu
Class hours:	Friday, 9:30 am -1:00 pm	**Location:** J335
Office hours:	Thursday, 2 pm or by appointment	

Course Content

This course will focus on product design, prototyping, entrepreneurship and the innovation process for wearable technology by emphasizing creation of solutions through team based projects. Student teams will utilize tools and skills such as computer-aided design, machining fabrication and sensor feedback to create prototypes of various types of wearable devices. They will investigate market interest in an open-ended wearable concept and communicate their solution's societal and economic benefits as well as technical, regulatory and manufacturing issues related to product design.

Course Instructional Format

The fundamental objective of this course is to allow student to learn by doing. Students will thus learn about the working principles, design, manufacture, and user reliability of wearable technology. The students will evaluate technical feasibility, economic value of proposed solutions as well the societal benefits of the outcomes. The course will be taught by faculty from various backgrounds to provide a broad perspective on Wearable Technology Ecosystem.

Textbook:

- Guler, Gannon and Sicchio, *Crafting Wearables: Blending Technology with Fashion (Technology in Action), 1st Edition*, ISBN-13: 978-1484218075 **(CW)**

Recommended References:

- Sazonov and Neuman, *Wearable Sensors: Fundamentals, Implementation and Applications 1st Edition,* ISBN-13: 978-0124186620 **(WS)**
- Norman, *The Design of Everyday Things*, 978-1452654126 **(DET)**
- Eppinger, *Product Design And Development*, ISBN-13: 978-9352601851 **(PD)**
- Hartman, Make: *Wearable Electronics: Design, prototype, and wear your own interactive garments 1st Edition,* ISBN-13: 978-1449336516 **(MWE)**

Studio Class Session Format (Total time = 3.5 hr/session)

i. Lecture – 30 min
ii. Cookbook Activity – 45 min
iii. Recap – 15 min
iv. Break – 5 min
v. Group Project – 90 min
vi. Reporting – 30 min

APPENDIX - A

Grading/Evaluation:

- **20% Attendance and Group Participation**
  - It is important that students attend the class on time. Missing days will hurt your grade in this course. Please contact the instructor for any and all anticipated absences, and especially emergencies relating to class attendance. The student will get an "F" after the second unexcused absence. Self and group participation will be assessed by students and faculty.

Participation Grade	Perfect Attendance	1 Absence	2 Absences	3 Absences	4 Absences
A	20%	18%	16%	14%	Fail
B	18%	16%	14%	12%	Fail
C	16%	14%	12%	10%	Fail
D	14%	12%	10%	8%	Fail
F	12%	9%	4%	2%	Fail

A = Fully engaged in class discussions. Asked and answered questions from instructor/class.
B = Mostly engaged in class and team discussions. Occasionally asked and answered questions from instructor and classmates. Occasionally distracted or engaged in other activities.
C = Only partially engaged in class discussions. Only responded when directly asked a question by the instructor. Occasionally distracted or engaged in other activities.
D = Rarely participated in class discussions. Only partially able to answer questions directly posed by professor. Frequently distracted or engaged in other activities.
F = Attended class but did not actively participate. Unable to answer questions directly posed.

- **30% Weekly Objective Recap and Pin Up Reviews**
  - Each weekly topic and hands-on activity will conclude with a recap of the objectives for that technology or skill. Each week the project deliverables for each group will be briefly shared with the class in a "pin up" review.
- **20% Skill-based Project Reports and Demonstrations**
  - The two mid-semester skill-based group projects will conclude with a summary report and demonstration to the class.
- **30% Final Project Portfolio**
  - The final open-ended group project will conclude with a "Kickstarter" type documentation portfolio and a formal marketing pitch presentation to the class and faculty contributors.

Learning objectives

- Identify needs and opportunities as well as the process of innovation in Wearable Technology.
- Identify constraints, human factors and best practices in the design of Wearable Technology.
- Collaborate in teams with defined roles and responsibilities and common goals to organize, plan and manage a product design project.
- Utilize technical tools and skills needed to create a viable design solution in terms of economic and social value.
- Explain the basic working principles of standard Wearable Technology devices.
- Report on the quality control, regulation, privacy and safety aspects of wearables.
- Investigate the effects of costs, customer feedback and market valuation in engineering design
- Communicate design status and results to all stakeholders in verbal, written, and public presentation formats at appropriate points in the development timeline.

Course conduct

Students should read, understand and comply with the Lawrence Technological University Student Code of Conduct. For more information see http://www.ltu.edu/student_affairs/student_conduct.asp

Academic Integrity

Student groups may discuss problems with others, but should write up their own solutions. Turning in work copied directly from other students is cheating. Exchange of information with others during projects is unacceptable. Any material included in assignments should not be taken from available resources verbatim and references must be listed. Also see http://www.ltu.edu/currentstudents/honor_code.asp

Tentative Calendar

Week	Date	Topics (30 min)	In Class Activity / Demonstration (60 min)	Group Project (120 min)
1	8/25	Introduction and Welcome	Virtual/Augmented Reality	Reverse Engineering
2	9/1	Textiles	Cutting, stitching, sewing machines	E-Textiles Intro
3	9/8	Basic Electronics	Soldering	Circuit design
4	9/15	Soft Circuits for Wearables	Soft Circuits	Pressure Switch
5	9/22	Microcontrollers for Wearables	Arduino / Lilypad	Smart Watch Intro
6	9/29	Sensor and Actuator	Temperature / Inertial sensors	Step Counter
7	10/6	Digital Design	3D Scanning to STL files	CAD Case
8	10/13	Digital Fabrication	Laser Cutting and CAM	3D Printing
9	10/20	Product Design and Social Aspects	Design thinking	Open Ended Intro
10	10/27	User Interface Design	Unity programming	Usability Design
11	11/3	Programming and Software Design	Leap and Unreal	Software Design
12	11/10	Data Processing	Using Big Data	Communications Design
13	11/17	Privacy and Security	Fair Information Practices	Sustainability Design
14	12/1	Design for Manufacturing	Commercialization	Fit and Finish Design
15	12/8	Product Design and Social Aspects	Business Model Generation	Communicate your Ideas
FE	TBA	Final Project Presentations		"Kickstarter" page and prototype

BME 3113 "Wearable Technology Studio" Syllabus (Fall 2020)

Instructors: Dr. Eric G. Meyer, J337, Biomedical Engineering, emeyer@ltu.edu — John Peponis, J134, Biomedical Engineering, jpeponis@ltu.edu

Studio/Office hours: Thursday, 1-3 pm or by appointment (Meyer); Monday, 10 - 1 pm or appointment (Peponis)

Class hours: **Section 01** Tuesday, 2:00 – 4:50 pm
Section 02 Thursday, 3:30 – 6:20 pm

Location: J335

Course Content

This course will focus on product design, prototyping, entrepreneurship and the innovation process for wearable technology by emphasizing creation of solutions through team based projects. Student teams will utilize tools and skills such as computer-aided design, machining fabrication and sensor feedback to create prototypes of various types of wearable devices. They will investigate market interest in an open-ended wearable concept and communicate their solution's societal and economic benefits as well as technical, regulatory and manufacturing issues related to product design.

Course Instructional Format

The fundamental objective of this course is to allow students to learn by doing. The class will follow a "mixed class" model with online and in-class active learning modules, student presentations and class discussion. Students will thus learn about the working principles, design, manufacture, and usability of wearable technology. The students will evaluate technical feasibility, economic value of proposed solutions as well the societal benefits of the outcomes.

Skill Building Sessions

- Individually complete the skill demonstration activity.
- A portfolio documenting each of the skill building processes will be submitted to Canvas at the end of class.

Interactive Presentations

- Review online topical reference materials and software tutorials that are provided each week on Canvas.
- Choose a specific example to explore in detail and create interactive explanation slides to share with the class.

Group Project Meetings

- Groups will be assigned for each project.
- Weekly meetings will introduce project goals and logistics.
- Groups will complete the assigned project deliverables outside of class times. Attendance at "Open Studio Hours" or a Zoom meeting with faculty during "Office Hours" is expected on a regular basis to complete fabrication and troubleshooting. These meetings should be scheduled in advance.
- Discussion board "Pin-Up Review" posts will facilitate peer feedback on initial ideas and designs.
- Project notebooks will document progress for the group will be submitted to Canvas on a biweekly basis.
- Projects will conclude with a demonstration of the final design in a short video to be shared on the course website. Other specific deliverables and documentation details will be provided for each project.

Materials and Resources

The hands-on nature of this course will require different materials for prototyping. Many of these materials will be provided by instructors (including conductive thread/fabric, sewing needles, LilyMini boards, CircuitPlayground Bluefruit boards, lithium batteries, adapters, LEDs, pedometers, etc.). Some materials may need to be sourced individually or as a team (including generic fabric, LED strips, foam, elastic bands, masks/face shields, microUSB chords, and generic tools such as screwdrivers). Students will be given individual kits of materials for use in class and at home. All tools and materials in the lab are available for student use in class and during open studio hours.

Learning objectives

- Identify needs and opportunities as well as the process of innovation in Wearable Technology.
- Identify constraints, human factors and best practices in the design of Wearable Technology.
- Collaborate in teams with defined roles and responsibilities and common goals to organize, plan and manage a product design project.
- Utilize technical tools and skills needed to create a viable design solution in terms of economic and social value.
- Report on the quality control, regulation, privacy and safety aspects of wearables.
- Communicate design status and results to all stakeholders in verbal, written, and public presentation formats at appropriate points in the development timeline.

Grading/Evaluation:

- **10% Attendance and Group Participation**
  - It is important that students attend the class on time. Missing days will hurt your grade in this course. Please contact the instructor for any and all anticipated absences, and especially emergencies relating to class attendance. The student will get an "F" after the second unexcused absence.

Participation Grade	Perfect Attendance	1 Absence	2 Absences
A	10%	8%	Fail
B	8%	6%	Fail
C	7%	5%	Fail
D	6%	4%	Fail
F	5%	3%	Fail

A = Fully engaged in class discussions. Asked and answered questions from instructor/class.

B = Mostly engaged in class and team discussions. Occasionally asked and answered questions from instructor and classmates. Occasionally distracted or engaged in other activities.

C = Only partially engaged in class discussions. Only responded when directly asked a question by the instructor. Occasionally distracted or engaged in other activities.

D = Rarely participated in class discussions. Only partially able to answer questions directly posed by professor. Frequently distracted or engaged in other activities.

F = Attended class but did not actively participate. Unable to answer directly posed questions.

- **30% Individual Coursework**
  - Skill building activities will require students to follow tutorials and complete a demonstration prototype. The activity process will be documented in a Skills Portfolio.
  - Online materials and software will be used to create interactive presentation slides about specific topics that can be shared with the other students.
- **20% Group Project Updates**
  - Each week there will be assigned project deliverables related to the topics discussed. Project documentation in the form of a group notebook will be submitted to Canvas.
  - Preliminary project ideas will be discussed with other students through Discussion Board "Pin-up Review" posts. Peer feedback will be used to update the project designs.
- **40% Project Presentations**
  - Three group projects will conclude with online documentation of specified deliverables including demonstration videos of the final design.
  - Self and group participation will be assessed by students and faculty.

Grading Scale:

A	> 93%
A-	90-92.9%
B+	87-89.9%
B	83-86.9%
B-	80-82.9%
C+	77-79.9%
C	73-76.9%
C-	70-72.9%
D+	67-69.9%
D	60-66.9%
F	<60%

Course conduct

Students should read, understand and comply with the Lawrence Technological University Student Code of Conduct. For more information see http://www.ltu.edu/student_affairs/student_conduct.asp

LTU requires every individual must wear a face covering over their nose and mouth when in any indoor public space. Public space is any shared or communal space such as a classroom, but not limited to, hallways, conference rooms, atriums, and laboratories.

Students who choose not to wear a face covering (mask) are in violation of the LTU Student Code of Conduct, Section C, Rules and Regulations 9. Violators will be sanctioned. Multiple violations will result in loss of privileges and suspension.

Academic Integrity

Violations of academic ethics will be handled according to University policies as set forth in the University's Academic Honor Code (see http://www.ltu.edu/currentstudents/honor_code.asp). Specific policies for assignments in this course are:

- All undergraduate students are required to write the following pledge on all academic work submitted along with a signature. If the pledge does not accompany an assignment, the faculty can choose to not grade it.

  "I have neither given nor received unauthorized aid in completing this work, nor have I presented someone else's work as my own."

- Students may discuss assignments with others, but should complete their own work and write up their own solutions. All assignments and reports must be by individual or group effort only. Plagiarism, without appropriate reference citation, will not be tolerated.

APPENDIX - B

Semester Schedule (tentatively)

Week	Dates Sec 1 Sec 2	Topics	Skill Building	Individual Assignments	Group Project	Project Deliverables
1	8/25 8/27	Wearables	*Google Docs*	Slides1	**Project 1:** "Emotive Mask"	Pinup1a
2	9/1 9/3	Textiles	**Sewing**	Portfolio1	Textile Prototype	Notebook1a
3	9/8 9/10	Basic Electronics	*Circuit Lab*	Slides2	Electronics Prototype	Pinup1b
4	9/15 9/17	Soft Circuits	**Soldering/ Lilypad**	Portfolio2	Soft Switch Prototype	Notebook1b
5	9/29 10/1	Microcontrollers	*Makecode*	Slides3	**Project 2:** "Mixed Reality Tracker"	**P1 Presentation**
6	10/6 10/8	Sensors/ Actuators	**Python**	Portfolio3	Programming Prototype	Notebook2a
7	10/13 10/15	3D Design	*TinkerCAD*	Slides4	Circuit Playground Prototype	Pinup2a
8	10/20 10/22	Manufacturing	**3D Printing**	Portfolio4	Case Prototype	Notebook2b
9	10/27 10/29	Disruptive Technology	*Tableau*	Slides5	**Project 3:** "Disruptive Tech"	**P2 Presentation**
10	11/3 11/5	Machine Learning	**PyTorch**	Portfolio5	AI Design	Notebook3a
11	11/10 11/12	User Interaction	*Google Forms*	Slides6	Hardware Design	Pinup3a
12	11/17 11/19	Software	**Adobe XD**	Portfolio6	App Design	Notebook3b
13	(online after	Privacy and Security		Slides7	Sustainability Design	Pinup3b
14	Thanks giving)	Product Development		Slides8	Business Model	Notebook3c
15		Crowd Funding		Slides9	"Kickstarter" page	
Finals			**Project 3 Presentation**			

BME 3113 "Wearable Technology Studio" Syllabus (Fall 2022)

Instructors: Dr. Eric G. Meyer
J337, Biomedical Engineering
emeyer@ltu.edu
Studio/Office hours: Thursday, 2-3 pm or by appointment
Class hours: Section 01 Tuesday, 2:00 – 4:50 pm

Course Content

This course will focus on product design, prototyping, entrepreneurship and the innovation process for wearable technology by emphasizing creation of solutions through team based projects. Student teams will utilize tools and skills such as computer-aided design, fabrication methods and sensor feedback to create prototypes of various types of wearable devices. Students will thus learn about the working principles, design, manufacture, and usability of wearable technology. They will investigate market interest in an open-ended wearable concept and communicate their solution's societal and economic benefits as well as technical, regulatory and manufacturing issues related to product design.

Course Instructional Format

The fundamental objective of this course is to allow students to learn by doing. The class will explore of various tools and resources for engineering design, participate in-class skill building activities, and complete group projects. Students will be assessed based on digital portfolios of individual work, group project notebooks, website documentations and presentations, as well as in-class and group participation.

Skill Building Activities

- Review online topical reference materials and tutorials that are provided each week on Canvas.
- Individually complete the skill demonstration activity.
- Organize an individual portfolio documenting each of the skill building processes.

Group Project

- Groups will be assigned for each project.
- Weekly updates with specified project goals and logistics.
- Groups will complete the assigned project deliverables outside of class times. Attendance at "Open Studio Hours" or a Zoom meeting with faculty during "Office Hours" is expected on a regular basis to complete fabrication and troubleshooting. These meetings should be scheduled in advance.
- "Pin-Up Review" presentations will facilitate peer feedback on initial ideas and designs.
- Group project notebooks documenting weekly progress will be submitted for grading.
- Projects will conclude with documentation of specified information as well as a group presentation and demonstration of the final design. Specific deliverables and documentation details will be provided for each project.

Materials and Resources

The hands-on nature of this course will require different materials for prototyping. Many of these materials will be provided by instructors (including textile materials, conductive thread/fabric, sewing needles, LilyMini boards, CircuitPlayground Bluefruit boards, lithium batteries, adapters, LEDs, pedometers, etc.). Some materials may need to be sourced individually or as a team (including generic fabric, LED strips, foam, elastic bands, microUSB cords, and generic tools such as screwdrivers). All tools and materials in the lab are available for student use in class and during open studio hours.

Learning objectives

- Identify needs and opportunities as well as the process of innovation in Wearable Technology.
- Identify constraints, human factors and best practices in the design of Wearable Technology.
- Collaborate in teams with defined roles and responsibilities and common goals to organize, plan and manage a product design project.
- Utilize technical tools and skills needed to create a viable design solution in terms of economic and social value.
- Report on the quality control, regulation, privacy and safety aspects of wearables.
- Communicate design status and results to all stakeholders in verbal, written, and public presentation formats at appropriate points in the development timeline.

Grading/Evaluation:

- **10% Attendance and Group Participation**
  - It is important that students attend the class on time. Missing days will hurt your grade in this course. Please contact the instructor for any and all anticipated absences, and especially emergencies relating to class attendance. The student will get an "F" after the second unexcused absence.

Participation Grade	Perfect Attendance	1 Absence	2 Absences
A	10%	8%	Fail
B	8%	6%	Fail
C	7%	5%	Fail
D	6%	4%	Fail
F	5%	3%	Fail

A = Fully engaged in class discussions. Asked and answered questions from instructor/class.
B = Mostly engaged in class and team discussions. Occasionally asked and answered questions from instructor and classmates. Occasionally distracted or engaged in other activities.
C = Only partially engaged in class discussions. Only responded when directly asked a question by the instructor. Occasionally distracted or engaged in other activities.
D = Rarely participated in class discussions. Only partially able to answer questions directly posed by professor. Frequently distracted or engaged in other activities.
F = Attended class but did not actively participate. Unable to answer directly posed questions.

- **30% Individual Coursework**
  - Skill building activities will require students to follow tutorials and complete a demonstration prototype. The activity process will be documented in a Skills Portfolio.
  - Online materials and software will be used to create interactive presentation slides about specific topics that can be shared with the other students.
- **20% Group Project Updates**
  - Each week there will be assigned project deliverables related to the topics discussed. Project documentation in the form of a group notebook will be submitted to Canvas.
  - Preliminary project ideas will be discussed with other students through "Pin-up Review" presentations. Peer feedback will be used to update the project designs.
- **40% Project Presentations**
  - Three group projects will conclude with documentation of specified deliverables and an in-class final design demonstration presentation.
  - Self and group participation will be assessed by students and faculty.

Grading Scale:

A	> 93%
A-	90-92.9%
B+	87-89.9%
B	83-86.9%
B-	80-82.9%
C+	77-79.9%
C	73-76.9%
C-	70-72.9%
D+	67-69.9%
D	60-66.9%
F	<60%

Course conduct

Students should read, understand and comply with the Lawrence Technological University Student Code of Conduct. For more information see http://www.ltu.edu/student_affairs/student_conduct.asp

Academic Integrity

Violations of academic ethics will be handled according to University policies as set forth in the University's Academic Honor Code (see http://www.ltu.edu/currentstudents/honor_code.asp). Specific policies for assignments in this course are:

- All undergraduate students are required to write the following pledge on all academic work submitted along with a signature. If the pledge does not accompany an assignment, the faculty can choose to not grade it.

  > *"I have neither given nor received unauthorized aid in completing this work, nor have I presented someone else's work as my own."*

- Students may discuss assignments with others, but should complete their own work and write up their own solutions. All assignments and reports must be by individual or group effort only. Plagiarism, without appropriate reference citation, will not be tolerated.

APPENDIX - C

Semester Schedule (tentatively)

Week	Dates	Topics	Individual Assignments	Group Project	Project Deliverables
1	8/23	Reverse Engineering	Google Slides	**Project 1:** "Light-up Costume"	Pinup
2	8/30	Textiles	Sewing	Textile Prototype	Group Notebook
3	9/6	3D Design/ Printing	TinkerCAD	Case Prototype	Pinup
4	9/13	Basic Electronics	Soldering	LED Prototype	"Instructable"
5	9/27	Circuits	Lilypad	**Project 2:** "Mixed Reality Tracker"	**P1 Presentation**
6	10/4	Microcontrollers	Adafruit Bluefruit	Programming Prototype	Pinup
7	10/11	Sensors/ Actuators	I/O Communication	Bluetooth Prototype	Group Notebook
8	10/18	User Interaction	Human Centered Design	Usability Design	Pinup
9	10/25	Industrial Design	Creativity	Fit and Finish Design	"User Manual"
10	11/1	Machine Learning	PyTorch	**Project 3:** "Disruptive Tech"	**P2 Presentation**
11	11/8	Big Data	Tableau	Data Engineering	Pinup
12	11/15	Software	Adobe XD	App Design	Group Notebook
13	11/22	Privacy and Security	Fair Information Practices	Sustainability	Pinup
14	11/29	Product Development	Manufacturing	Hardware Design	Group Notebook
15	12/6	Entrepreneurship	Business Model	Commercialization	"Kickstarter" page
Finals	TBD				**P3 Presentation**

APPENDIX - D

BME 3113 "Wearable Technology Studio" Syllabus (Fall 2024)

Instructor: John Peponis
J134-A, Biomedical Engineering
jpeponis@ltu.edu

Eric Meyer
J337, Biomedical Engineering
emeyer@ltu.edu

Austin Thomas
athomas3@ltu.edu

Studio/Office hours: TBD
Class hours: Section 01 Tuesday, 2:00 – 4:50 pm

Course Content

This course will focus on product design, prototyping, entrepreneurship and the innovation process for wearable technology by emphasizing creation of solutions through team-based projects. Student teams will utilize tools and skills such as computer-aided design, fabrication methods and sensor feedback to create prototypes of various types of wearable devices. Students will thus learn about the working principles, design, manufacture, and usability of wearable technology. They will investigate market interest in an open-ended wearable concept and communicate their solution's societal and economic benefits as well as technical, regulatory and manufacturing issues related to product design.

Course Instructional Format

The fundamental objective of this course is to allow students to learn by doing. The class will explore of various tools and resources for engineering design, participate in-class skill building activities, and complete group projects. Students will be assessed based on digital portfolios of individual work, group project notebooks, website documentations and presentations, as well as in-class and group participation.

Skill Building Activities

- Review online topical reference materials and tutorials that are provided each week on Canvas.
- Individually complete the skill demonstration activity.
- Organize an individual portfolio documenting each of the skill building processes.

Group Project

- Groups will be assigned for each project.
- Weekly updates with specified project goals and logistics.
- Groups will complete the assigned project deliverables outside of class times. Attendance at "Open Studio Hours" or a Zoom meeting with faculty during "Office Hours" is expected on a regular basis to complete fabrication and troubleshooting. These meetings should be scheduled in advance.
- "Pin-Up Review" presentations will facilitate peer feedback on initial ideas and designs.
- Group project notebooks documenting weekly progress will be submitted for grading.
- Projects will conclude with documentation of specified information as well as a group presentation and demonstration of the final design. Specific deliverables and documentation details will be provided for each project.

Materials and Resources

The hands-on nature of this course will require different materials for prototyping. Many of these materials will be provided by instructors (including textile materials, conductive thread/fabric, sewing needles, LilyMini boards, CircuitPlayground Bluefruit boards, lithium batteries, adapters, LEDs, pedometers, etc.). Some materials may need to be sourced individually or as a team (including generic fabric, LED strips, foam, elastic bands, microUSB cords, and generic tools such as screwdrivers). All tools and materials in the lab are available for student use in class and during open studio hours.

APPENDIX - D

Learning objectives

- Identify needs and opportunities as well as the process of innovation in Wearable Technology.
- Identify constraints, human factors and best practices in the design of Wearable Technology.
- Collaborate in teams with defined roles and responsibilities and common goals to organize, plan and manage a product design project.
- Utilize technical tools and skills needed to create a viable design solution in terms of economic and social value.
- Report on the quality control, regulation, privacy and safety aspects of wearables.
- Communicate design status and results to all stakeholders in verbal, written, and public presentation formats at appropriate points in the development timeline.
- Recognize the contribution of science, technology, engineering and/or mathematics to society

Grading/Evaluation:

- **10% Attendance and Group Participation**
  - It is important that students attend the class on time. Missing days will hurt your grade in this course. Please contact the instructor for any and all anticipated absences, and especially emergencies relating to class attendance. The student will get an “F” after the second unexcused absence.

Participation Grade	Perfect Attendance	1 Absence	2 Absences
A	10%	8%	Fail
B	8%	6%	Fail
C	7%	5%	Fail
D	6%	4%	Fail
F	5%	3%	Fail

A = Fully engaged in class discussions. Asked and answered questions from instructor/class.
B = Mostly engaged in class and team discussions. Occasionally asked and answered questions from instructor and classmates. Occasionally distracted or engaged in other activities.
C = Only partially engaged in class discussions. Only responded when directly asked a question by the instructor. Occasionally distracted or engaged in other activities.
D = Rarely participated in class discussions. Only partially able to answer questions directly posed by professor. Frequently distracted or engaged in other activities.
F = Attended class but did not actively participate. Unable to answer directly posed questions.

- **30% Individual Coursework**
  - Skill building activities will require students to follow tutorials and complete a demonstration prototype. The activity process will be documented in a Skills Portfolio.
  - Online materials and software will be used to create interactive presentation slides about specific topics that can be shared with the other students.
- **20% Group Project Updates**
  - Each week there will be assigned project deliverables related to the topics discussed. Project documentation in the form of a group notebook will be submitted to Canvas.
  - Preliminary project ideas will be discussed with other students through “Pin-up Review” presentations. Peer feedback will be used to update the project designs.
- **40% Project Presentations**
  - Three group projects will conclude with documentation of specified deliverables and an in-class final design demonstration presentation.
  - Self and group participation will be assessed by students and faculty.

Grading Scale:

A	> 93%
A-	90-92.9%
B+	87-89.9%
B	83-86.9%
B-	80-82.9%
C+	77-79.9%
C	73-76.9%
C-	70-72.9%
D+	67-69.9%
D	60-66.9%
F	<60%

Course conduct

Students should read, understand and comply with the Lawrence Technological University Student Code of Conduct. For more information see http://www.ltu.edu/student_affairs/student_conduct.asp

Academic Integrity

Violations of academic ethics will be handled according to University policies as set forth in the University's Academic Honor Code (see http://www.ltu.edu/currentstudents/honor_code.asp). Specific policies for assignments in this course are:

- All undergraduate students are required to write the following pledge on all academic work submitted along with a signature. If the pledge does not accompany an assignment, the faculty can choose to not grade it.

  "I have neither given nor received unauthorized aid in completing this work, nor have I presented someone else's work as my own."

- Students may discuss assignments with others, but should complete their own work and write up their own solutions. All assignments and reports must be by individual or group effort only. Plagiarism, without appropriate reference citation, will not be tolerated.

APPENDIX - D

Semester Schedule (tentatively)

Week	Dates	Topics	Individual Assignments	Group Project	Project Deliverables
1	8/27	What is Wearable Tech?	Teardown Wearable Profile	**Project 1:** "Light-up Costume"	Ideation, Design Sketch, LoFi Prototype
2	9/3	Textiles	Hand Stitching Sewing Machine	Textile Design	Textile Prototype
3	9/10	Circuits and Electronics	TinkerCAD Circuits Blue Devil Boards	LED/Battery Design	LED Prototype
4	***9/17***	***NO CLASS***	***ASSESSMENT DAY***		
5	9/24	3D Design/ Printing	TinkerCAD + Mechanisms	"Case" Design	Instructable
6	10/8	Microcontrollers + Sensors/Actuators	Adafruit Bluefruit	**Project 2:** "Mixed Reality Tracker"	**P1 Presentation**
7	10/15	Peripherals + Communication	Bluetooth	Programming Prototype	Pinup: Design Concept / Code
8	10/22	User Interaction / HCD	Accessibility Design	Usability/UX Design	GN: UX Design
9	10/29	Industrial Design and Ergonomics	Ergonomics	"Fit and Finish" Design	Pinup: Industrial Design
10	10/24	Tech Revolutions	Extended Reality	**Project 3:** "Wearable Assistant"	**P2 Presentation**
11	10/31	Machine Learning	PyTorch	Algorithm Design	Algorithm Design
12	11/5	Big Data	Data Visualization	Data Engineering	Data Display
13	11/12	Software	Adobe XD	App Design	App Design
14	11/19	Privacy and Security	Fair Information Practices	Sustainability	Privacy Policy
15	11/26	Product Development	Manufacturing	Hardware Design	Hardware Design
16	12/3	Entrepreneurship	Business Model	Commercialization	"Kickstarter" page
17	12/10	TBD			
FINAL	12/18	1:30PM – 3:30PM			**P3 Presentation**

APPENDIX - D

APPENDIX - E

GENERAL CARD #1449

Building Interactive Wearable Technology Devices to Motivate Hands-on Experience with Biomechanics and Biomedical

By Eric Meyer

Updated: 7/24/2018 2:52 PM by Eric Meyer

Summary

Wearable technology is stimulating innovation and can inspire students.

Mindset Matters

Curiosity

- Demonstrate constant curiosity about our changing world
- Explore a contrarian view of accepted solution

Connections

- Integrate information from many sources to gain insight
- Assess and manage risk

Creating Value

- Identify unexpected opportunities to create extraordinary value
- Persist through and learn from failure

Skillset

Design

- Determine Design Requirements
- Develop New Technologies
- Perform Technical Design
- Create Model or Prototype
- Analyze Solutions
- Validate Functions

Opportunity

- Identify Opportunity
- Evaluate Tech Feasibility, Customer Value, Societal Benefits & Economic Viability
- Investigate Market
- Test Concepts via Customer Engagement
- Create Preliminary Business Model
- Assess Policy & Regulatory Issues

Impact

- Communicate Solution in Economic Terms
- Develop Partnerships & Build Team
- Communicate Societal Benefits
- Identify Supply Chains & Distribution Methods

Categories & Tags

Engineering Disciplines

- Arts & Sciences
- Biomedical Engineering
- Engineering Education
- General Engineering

Authors

Eric Meyer
Lawrence Technological University

Description

Technology is moving from large/stationary systems controlled by keyboards to light wearable (or implanted) devices that allow for new ways of interacting with information. This next industrial revolution is blurring the boundaries between the physical and digital worlds for the users. Human kinematics and kinetics measurements that previously required "gait lab" setup is already available in video game and virtual/augmented reality systems, health and wellness trackers, clothing, shoes and sports equipment. To keep pace with these advancements, the technologies should be utilized for new learning opportunities in biomechanics courses and biomedical engineering design curricula.

We developed a new "studio" format product design course that featured hands-on, skill-building modules and a sequence of group projects around wearable technology. The goal was to promote the fundamental biomechanics concepts while simultaneously enabling students to develop confidence in working with various types of sensors that are the backbone of many wearable devices. The projects included a light-up slipper, a personal fitness tracker and student-selected open-ended design project. Additional prototyping skill modules included basic sewing and soldering, electronics design with soft circuits, Arduino® programming, and rapid manufacturing. Learning outcomes were assessed periodically and the instructors' reflections were gathered for future improvements to the modules and projects.

The light-up slipper project focused on use of conductive fabric. Future iterations will require a pressure-sensitive or stretch switch that is activated during walking. The fitness tracker required students to use physical sensors and create an algorithm for counting individual steps. The final project promoted innovative design while taking issues of usability and appeal of wearable device concepts into consideration.

Most students, despite their prior lack of experience with electronics, were able to create functional prototypes that used sensors to activate or provide feedback related to human biomechanics. Student feedback showed that they enjoyed the hands-on aspects of the skill-building modules and the open-ended, real world nature of the projects. Instructional difficulties included development of appropriate material resources and the required expertise for some modules. This course was part of a larger project to implement entrepreneurial-minded learning into a variety of engineering courses so that students are repeatedly exposed to the innovator's mindset. The ultimate goal is to improve student learning outcomes and skills for their senior capstone projects as well as real-world ready professionals.

Learning Objectives

- Define problems, opportunities, and solutions in terms of value creation.
- Anticipate technical developments by interpreting surrounding societal and economic trends.
- Identify new business opportunities.
- Apply creative thinking to ambiguous problems.
- Apply systems thinking to complex problems.
- Examine technical feasibility, economic drivers, and societal and individual needs.
- Communicate engineering solutions in economic terms and with regard to societal benefits.
- Substantiate claims with data and facts.
- Collaborate in a team setting.

Instructor Tips

The KEEN Entrepreneurial Mindset framework (Melton, 2014) emphasizes that students should be supported so that they can "create value, gather and assimilate information to discover opportunities or insights for further action." While standard engineering curriculum and classes lack student experiences with entrepreneurship skills in the Opportunity and Communications columns, KEEN believes that Entrepreneurship is a Mindset and that the Entrepreneurship Process can be Formalized. This project-based course requires deep immersion into a real world, exciting and accessible topic to allow students the opportunity to build confidence with their entrepreneurship skills (Curiosity). Multi-disciplinary instruction expands the students' capabilities to create solutions across a broad variety of real-world opportunities (Connections). Students are expected to seek out customer needs and deliver solutions that address the social, economic and environmental impacts (Creating Value).

Since the 1960's until the early 2000's, undergraduate curriculum in engineering have trended from skill-based, applied approaches towards a more theoretical and scientific knowledge focus. Engineering faculty that emphasized real world practitioner experiences and integrative, team-based development approaches were gradually lost. Expectations for faculty became heavily concentrated on research activities with a mindset that rewarded reductionist efforts made by individuals. This resulted in engineering student education that tried to pack as much information transfer into the degree as possible. Therefore, many engineering faculty are hesitant to consider pedagogical approaches that take away time from lectures (Froyd et al., 2012). Students are expected to memorize the material or work many examples and their mastery is then evaluated during an exam. This teaching method of proposing a concept, explaining the principles and demonstrating mathematical models of the concept lacks important student learning opportunities, such as; the reason why these concepts or mathematics are important, what is their real-world relevance and how this will impact the students' future career in engineering.

On the other hand, inductive pedagogies like Active Collaborative Learning (ACL), Project Based Learning (PBL) (Smith et al., 2005), and Entrepreneurial Minded Learning (EML) (Kriewall and Mekemson, 2010) are more student-centered and begin with a real-world problem or observation that is introduced to the students. These techniques and can lead to deeper student learning when properly implemented (Prince, 2004). Recently, engineering education leaders have called for curriculum reform that provides students with repeated design-implement experiences as a more authentic context for learning fundamental science content, engineering principles and analytical capabilities (Crawley et al., 2014). The aim is to develop students who are better at adapting to new trends, embracing creativity and leadership, understanding engineering impacts on society and business, as well as providing more opportunities to experience engineering design (Fairweather, 2008). Engineering design courses at the freshman or senior levels are the most common way that universities use to give students opportunities to work on real world engineering problems.

Studio courses are common in the College of Architecture and Design at LTU, but have been recommended for integration into other academic fields, including engineering (Svinicki and McKeachie, 2011). Of particular relevance for the current course were studios in the Industrial Design program, which were used for benchmarking the resources, pedagogy and student assessment methods that were implemented. Studio courses typically integrate content delivery, hands on activity, and discussion into one scheduled class period held in a single room (Perkins, 2005). The studio instruction space is flexible to enhance collaboration and innovation (Moody, 2011). Lecture is limited while experiential learning and the production of “real world” artifacts using a structured design process are emphasized. Studio courses require more contact time than traditional engineering courses, so there were 4 contact hours per week for this course. The number of students per section should limited to less than 30 students and two or more faculty “team-teaching” is beneficial. Frequently, these courses designate a relevant design theme that allows the students to identify shared opportunities and encourage student ownership. Finally, it is important to celebrate accomplishments at the end of the studio experience with an exposition that includes faculty and industrial representatives.

The traditional pedagogical approach in engineering starts with building a strong foundation in math and sciences before introducing laboratory coursework that demonstrates these principles though representative theoretical and experimental models. Students learn deductively and appreciate the careful caution exhibited by a developer in ascertaining that the solution is reliable and accurate. Although the learn-implement-build-test technique is necessary for communicating large amounts of technical information, it lacks the real-world relevance and use of available resources necessary for product design. Furthermore, technical competence is not enough to address the practical considerations successful product design.

Recent developments in the maker movement have opened the door for hobbyists, inventors and hackers to turn concepts into products by focusing on technology gaps and customer needs through rapid prototyping. The end products demonstrate the entrepreneurial spirit and on-demand learning through repeated trials and failure, which is in contrast to a more calculated engineering approach.

Technology companies are playing their part in supporting this interest by developing new wearable product development with hardware and software development kits that reduce the time and expenses required to apply this technology in new and creative ways. The open hardware and plug-in sensor motes are portable, easily configurable and can be cascaded for more complex measurement schemes. In addition, there are many cost-effective sensor kits with modules to measure a variety of environmental and physiological parameters, are now available on the market. Many kits also come with instructional manuals that make it easy for novices or non-technical users.

This course, incorporating aspects of maker movement, fills a gap in the current engineering coursework that motivates the next generation of students to make preliminary models, create prototypes, find limitations and develop business plans with targeted markets around the novelty in a new product. The studio format utilizes inductive pedagogy and experiential learning that follows a design-build-test-reflect technique and develops many of the characteristics of the maker movement.

Designed to focus on product design, this course will introduce various aspects of wearable technology to students, with minimal prerequisites, by a team of multi-disciplinary faculty from engineering, industrial design, information technology, and humanities. Using an experiential learning pedagogy within the framework of the entrepreneurial mindset, this elective course will espouse curiosity and build self-confidence in students that is necessary to emphasize innovation skills (associating, questioning, observing, experimenting, and networking) and the variety of roles (designer, manager, maker, professional, role model, and value creator) necessary in entrepreneurship. The major topics in the course are roughly: Social aspects, Sensor technology, Prototyping skills, Software, Data analysis and Product design.

The “Wearable Technology Studio” course introduces students to the concepts and fundamental techniques that are relevant to product design of wearables, including; open electronics microcontrollers, switches, sensors/actuators, displays, LEDs, motors, wireless communication, and programming. The class has minimal prerequisite programming or electronics knowledge. The studio format includes a combination of interactive demonstration sessions, simple cookbook recipe projects, and two guided design projects for the first eight weeks of the semester. This sequence of culminates in a midterm project to 3D print and assemble a 'fitness tracker'. The fitness tracker/smart watch project demonstrate the failure of the "maker" approach to create desirable consumer products as it will be very rough and clunky.

During the final seven weeks, students form groups and complete a self-determined wearable technology product development project. The final project includes the topics of user interaction, wireless connection to a mobile device, mobile app development, materials and manufacturability, funding, marketing and differentiation from competing products. Direct and indirect assessments have been developed to analyze the modules and projects. The emphasis for the final project is not to produce a functional device, but on developing a good product concept that customers would want to buy, wear, and use. We encourage that some of the engineers taking this course may choose to continue with their product idea for their Senior Project. This gives them the time to really develop the engineering design and build a functioning device. We also push groups to enter the campus business incubator programs to develop the commercialization aspects of their products.

References & Acknowledgements

Lawrence Technological University Faculty contributing to this course: Mansoor Nasir Biomedical Engineering Eric Meyer Biomedical Engineering Franco Delogu Psychology Daniel Shargel Philosophy Justin Ku Information Technology Bryce Evans Game Art

Funding was provided by: Kern Entrepreneurship Education Network (KEEN) Topical Grants and the LTU Institutional Grant

This work was presented at the 2018 World Congress of Biomechanics in Dublin, Ireland.

Folders

Course Development Materials

Description

Title	Type	Ext	Date	Size	Download All	Downloads
2018WCBPresentation_BuildingInteractiveWearableTech.pdf	Presentation	.pdf	7/24/2018	10.7 MB	Download	2
FacultyKickoffMeetingReview.pdf	Instructor Notes	.pdf	7/24/2018	885.5 KB	Download	1
BME4903_Syllabus F2017.pdf	Syllabus	.pdf	7/24/2018	240.9 KB	Download	0
BME4903_TenativeCalendar.pdf	Instructor Notes	.pdf	7/24/2018	387 KB	Download	1

Wearable Technology Project Assignments

Description

Title	Type	Ext	Date	Size	Download All	Downloads
Project0_VirtualRealityEship.pdf	Activity / Handout	.pdf	7/24/2018	111.2 KB	Download	1
Project1_ElectronicSlipper_Week1.pdf	Activity / Handout	.pdf	7/24/2018	309.7 KB	Download	1
Project1_ElectronicSlipper_Week2.pdf	Activity / Handout	.pdf	7/24/2018	99.4 KB	Download	0

APPENDIX - E

Project1_ElectronicSlipper_Week3andFinal.pdf	Activity / Handout	.pdf	7/24/2018	204.5 KB	Download	1
Project2_FitnessTracker_Week1.pdf	Activity / Handout	.pdf	7/24/2018	98.2 KB	Download	0
Project2_FitnessTracker_Week2.pdf	Activity / Handout	.pdf	7/24/2018	98.3 KB	Download	0
Project2_FitnessTracker_Week3andFinal.pdf	Activity / Handout	.pdf	7/24/2018	298.7 KB	Download	0
Project3_DisruptiveWearableTechnology_Week1.pdf	Activity / Handout	.pdf	7/24/2018	210.7 KB	Download	1
Project3_DisruptiveWearableTechnology_Week2.pdf	Activity / Handout	.pdf	7/24/2018	192.4 KB	Download	1
Project3_DisruptiveWearableTechnology_Week3.pdf	Activity / Handout	.pdf	7/24/2018	302.9 KB	Download	0
Project3_DisruptiveWearableTechnology_Week4.pdf	Activity / Handout	.pdf	7/24/2018	193.2 KB	Download	0
Project3_DisruptiveWearableTechnology_Week5.pdf	Activity / Handout	.pdf	7/24/2018	348.2 KB	Download	0
Project3_DisruptiveWearableTechnology_Week6.pdf	Activity / Handout	.pdf	7/24/2018	198.8 KB	Download	0
Project3_DisruptiveWearableTechnology_FinalRequirements.pdf	Activity / Handout	.pdf	7/24/2018	330.9 KB	Download	0
Grading Rubric for Project 3.pdf	Assessment / Rubric	.pdf	7/24/2018	70.5 KB	Download	0

Project Student Work Examples

Description

Project 3 Kickstarter Pages can be viewed at https://www.ltu.edu/blogs/wearabletech/

Title	Type	Ext	Date	Size	Download All	Downloads
Project 1 Final Presentation_Example1.pdf	Student Artifact / Example	.pdf	7/24/2018	603.7 KB	Download	0
Project 1 Final Presentation_Example2.pdf	Student Artifact / Example	.pdf	7/24/2018	854.7 KB	Download	0
Project 1 Final Presentation_Example3.pdf	Student Artifact / Example	.pdf	7/24/2018	2.1 MB	Download	0
Project2Examples.pdf	Student Artifact / Example	.pdf	7/24/2018	749.8 KB	Download	0
Sleepy Bear Promo Video.mp4	Student Artifact / Example	.mp4	7/24/2018	8.8 MB	Download	0
FIND-ME-VIDEO.mov	Student Artifact / Example	.mov	7/24/2018	7.2 MB	Download	0

Citation

Meyer, Eric. 2018. "Building Interactive Wearable Technology Devices to Motivate Hands-on Experience with Biomechanics and Biomedical Engineering Design". Engineering Unleashed. July 24, 2018. https://engineeringunleashed.com/card/1449

APPENDIX - F

0 | 0 Favorites | 0 Times Used | 0 Shares | 4 Downloads

CLASSROOM CARD #4628

Reverse Engineering Module in Wearable Technology Design

By Eric Meyer & 2 others

Updated: 2/19/2025 3:24 PM by Eric Meyer

Summary

What is Wearable Tech? This is an introduction to product design through a reverse engineering teardown analysis of an existing product.

Course

BME 3113 "Wearable Technology Studio"

Course Content

This course will focus on product design, prototyping, entrepreneurship and the innovation process for wearable technology by emphasizing creation of solutions through team-based projects. Student teams will utilize tools and skills such as computer-aided design, fabrication methods and sensor feedback to create prototypes of various types of wearable devices. Students will thus learn about the working principles, design, manufacture, and usability of wearable technology. They will investigate market interest in an open-ended wearable concept and communicate their solution's societal and economic benefits as well as technical, regulatory and manufacturing issues related to product design.

Course Instructional Format

The fundamental objective of this course is to allow students to learn by doing. The class will explore of various tools and resources for engineering design, participate in-class skill building activities, and complete group projects. Students will be assessed based on digital portfolios of individual work, group project notebooks, website documentations and presentations, as well as in-class and group participation.

.

Mindset Matters

Curiosity

- Demonstrate constant curiosity about our changing world

Connections

- Integrate information from many sources to gain insight

Creating Value

- Identify unexpected opportunities to create extraordinary value

Skillset

Design

- Determine Design Requirements
- Analyze Solutions
- Validate Functions

Opportunity

- Identify Opportunity
- Evaluate Tech Feasibility, Customer Value, Societal Benefits & Economic Viability
- Investigate Market

Impact

- Communicate Solution in Economic Terms
- Communicate Societal Benefits

Categories & Tags

Category

- Classroom & Courses

Tags & Keywords

- design
- reverse engineering
- wearable technology
- product design
- case studies

Engineering Disciplines

- Entrepreneurship
- General Engineering
- Health Sciences & Medical

Authors

Eric Meyer
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John Peponis
Lawrence Technological University
Unfollow

Austin Thomas
Lawrence Technological University
Unfollow

APPENDIX - F

Time

45 to 90 minutes

Materials

Students will need a screwdriver, a cheap pedometer (or some other device from home that you can take apart) and a camera. They will need to use your computer to create a parts list, teardown instructions and process diagram of the pedometer components and assembly.s, website documentations and presentations, as well as in-class and group participation.

Description

Pre-class work was for the students to watch videos and review other product design related material online (see links in Attachments) and complete a discussion board assignment. We use these short reflections as a way to share resources and other background information related to the in class skill activities each week.

During class the students worked with a partner to complete the skill building activity: a reverse engineering teardown of a cheap pedometer. We also showed teardowns of other devices that we had in the lab to compare similar components and the unique sensor for the pedometer versus a device like a thermometer.

Procedure:

Brainstorm all the components that you expect to find in the device before you take it apart. Write them down and show the instructor to claim your materials.

Reverse Engineering Steps

1. Check that your device is functional.
2. Document the steps to disassemble and how each component was connected together.
3. Produce a list of all components and the number of similar components (use actual names when possible).
4. Describe each component's function, estimate the costs, and identify potential suppliers or the likely manufacturing processes.
5. Produce a process diagram for how the pedometer and selected components work.

Then as an individual homework assignment each student identified a wearable technology device that was interesting and that wanted to learn about and share with the class. They searched online for the product's webpage, reviews, teardowns, ect. They also considered their own first hand knowledge if they owned the device or knew someone who does.

A good source for wearable device teardowns is to search on the Adafruit Youtube channel or iFixit.com and other teardown/troubleshooting websites.

The homework deliverable was to create an interactive, shared Google presentation with 10 slides;

1. Title
2. Clickable Diagram (menu)
3. Value Proposition
4. User Inputs and Outputs
5. Mobile App Connectivity
6. Retail/Business Strategy
7. Hardware Components
8. Fabrication and Assembly
9. Your personal Review
10. References and links to sources

The presentation template and example were provided and then the students shared their teardowns with the other students to review and comment on in the course discussion board.

Instructor Tips

APPENDIX - F

Keep the tools and other reverse engineering activity materials in an easily accessible location in the studio, so the students can find them and get familiar with where everything is or asking for help/materials when needed.

Walk around and ask prompting questions during the teardowns to get students thinking and understanding what they find or where to go to get more information when a component is not obvious. Show them other devices that have already been taken apart or ask them to reassemble the device if they complete the activity.

Assessment

The in-class teardown activity requires each student to follow the reverse engineering steps and submit a reflection summary that must include the following:

- Pictures of your disassembly methods.
- Components list.
- Process diagram for how components work together

The required homework slides were posted and follow up discussion posts were graded for participation.

Examples of student work are shown in the Attachments.

Folders

Student Assignments/Activities

Description

Title	Type	Ext	Date	Size	Download All	Downloads
In Class Activity_ Reverse Engineering of a Pedometer.pdf	Activity / Handout	.pdf	11/12/2024	34.8 KB	Download	1
PedometerTeardownGuide.pdf	Activity / Handout	.pdf	11/12/2024	174.7 KB	Download	0
Discussion Board_ Design Process Reflection.pdf	Activity / Handout	.pdf	11/12/2024	33.2 KB	Download	2
DesignThinking-Worksheet_Costume.pdf	Activity / Handout	.pdf	11/12/2024	108.3 KB	Download	0
Homework Assignment 1: Wearable Devices Investigation	Assessment / Rubric	.pdf	11/12/2024	51.6 KB	Download	1
Example Homework Assignment	Activity / Handout	.pdf	11/12/2024	3.1 MB	Download	0
Homework Powerpoint Template	Activity / Handout	.pptx	11/12/2024	300.1 KB	Download	0
Pedometer Disassembly Reflection Student Example.pdf	Student Artifact / Example	.pdf	2/19/2025	141.4 KB	Download	0
Wearable Devices Interactive Presentation Student Example.pdf	Student Artifact / Example	.pdf	2/19/2025	442.4 KB	Download	0

Supplemental Links/Materials

Description

Title	Type	Ext	Date	Size		Downloads
https://www.youtube.com/watch?v=m4hdtSyyigc	Video		2/19/2025	-	Link	
https://www.youtube.com/watch?v=E0GufWmT4mU	Video		11/12/2024	-	Link	
https://www.wearabletechnologyinsights.com/	Journal / Article		11/12/2024	-	Link	
https://modelthinkers.com/playbook/design-lessons-from-big-tech	Journal / Article		11/12/2024	-	Link	

APPENDIX - F

https://www.youtube.com/watch?v=E0GufWmT4mU	Video	2/19/2025	-	Link

Related

Wearable Technology Studio Modules

Description

Item Type	Card Title	Date Referenced	
Card	Building Interactive Wearable Technology Devices to Motivate Hands-on Experience with Biomechanics and Biomedical Engineering Design	2/19/2025	View

Citation

Meyer, Eric, Peponis, John, and Thomas, Austin. 2025. "Reverse Engineering Module in Wearable Technology Design". Engineering Unleashed. February 19, 2025. https://engineeringunleashed.com/card/4628

APPENDIX - G

Lawrence Technological University

BME3113 "Wearable Technology Studio"

Project 1 Final Presentation Grading Rubric

Names ____________________ ____________________ ____________________

Team Name (Brand):

Assignment Details					
Criteria	Does Not Meet Expectations	Meets Expectations	Exceed Expectations	Points	Score
Brainstorming Ideas/Specifications	Incomplete, little effort.	Good effort, mostly complete.	Clear ideas and reflection.	5	
Describe the value propositions and need statement for this system.	Inadequate description of product and users.	Some description of product and users.	Detailed description of product and users.	5	
Describe the hardware components included with this device.	Incomplete design and details of components.	Partial schematics of design and details of components.	Comprehensive schematics of design and details of all components.	5	
Describe the function of how components work together.	Poorly documented and unjustified. Descriptions are incomplete.	Processes documented. Usability has been considered.	Processes are justified. Usability details are described.	5	
Final Sewing Part Quality	Poor quality, lack of details.	Inconsistent quality, some details.	Good quality with highly detailed features.	5	
Final 3D Part Quality	Poor quality, lack of details.	Inconsistent quality, some details.	Good quality with highly detailed features.	5	
Final Lights Part Quality	Poor quality, lack of details.	Inconsistent quality, some details.	Good quality with highly detailed features.	5	
Functional Prototype	Missing or dysfunctional prototype. Missing fabrication methods.	Partially functional prototype. Only marginally uses required skills.	Prototype performs function. Fabricated using sewing, integrates 3D printing and LEDs.	10	
Form Factor/Product Design	Poor quality, lack of details.	Inconsistent quality, some details.	Final design organized and well-explained.	5	
Sketches/Models/Diagrams	Poor quality, lack of details.	Inconsistent quality, some of the details.	Good quality with highly detailed features.	5	
Lessons Learned/Future Work	Little reflection on work or strengths/weaknesses. Implications are ignored.	Some reflection and implications are discussed. Continuation work is identified.	Strengths/weaknesses stated. Implications of work are discussed. Suggested improvements.	5	
Final Pitch Presentation	Incomplete, little effort.	Good effort, mostly complete.	Highly motivated, detailed. Engaging with good slide design.	10	
Instructables Guide	Incomplete or missing steps/information.	Some description of materials and equipment. Somewhat clear instructions.	Complete materials and equipment description. Well-ordered steps. Clear instructions.	20	
Management/ Execution	Very little effort put into the project.	Good work ethic, team-effort.	Highly motivated. Good distribution of work.	10	

Total (100 pts) _________

Specific Comments

APPENDIX - H

Lawrence Technological University

BME3113 "Wearable Technology Studio"

Project 2 Grading Rubric

Names ____________________ ____________________ ____________________

Team Name (Company name):

Assignment Details					
Criteria	Does Not Meet Expectations	Meets Expectations	Exceed Expectations	Points	Score
Brainstorming Ideas/Specifications	Incomplete, little effort.	Good effort, mostly complete.	Clear ideas and reflection.	5	
Describe the value propositions and need statement for this system.	Inadequate description of product and users.	Some description of product and users.	Detailed description of product and users.	10	
Describe the hardware components included with this device.	Incomplete design and details of components.	Partial schematics of design and details of components.	Comprehensive schematics of design and details of all components.	10	
Describe the function of how components work together.	Poorly documented and unjustified. Descriptions are incomplete.	Processes documented. Usability has been considered.	Processes are justified. Usability details are described.	10	
Sensor/Tracking Function	Poor quality, lack of details.	Inconsistent quality, some details.	Quality description of how actions were defined and calibrated.	10	
Form Factor/Product Design	Poor quality, lack of details.	Inconsistent quality, some details.	CAD work and final design organized and well-explained	10	
Wireless Communication Design	Poor quality, lack of details.	Inconsistent quality, some details.	Processing and connection to App is detailed.	10	
How-To Video Demonstration	Missing or dysfunctional prototype lack of details.	Partially functional prototype, some details.	Illustrated idea and operation of the product. Prototype performs function.	10	
Sketches/Models	Poor quality, lack of details.	Inconsistent quality, some of the details.	Good quality with highly detailed features.	5	
Lessons Learned/Future Work	Little reflection on work or strengths/weaknesses. Implications are ignored.	Some reflection and implications are discussed. Continuation work is identified.	Strengths/weaknesses stated. Implications of work are discussed. Suggested improvements.	5	
Final Pitch Presentation	Incomplete, little effort.	Good effort, mostly complete.	Highly motivated, detailed. Engaging and organized.	10	
User Manual	Confusing and gaps in the details.	Some illustration of concept. Quality fair.	Good quality with highly detailed features.	20	
Management/ Execution	Very little effort put into the project.	Good work ethic, team-effort.	Highly motivated. Good distribution of work.	10	

Total (125 pts) _________

Specific Comments

APPENDIX - I

Lawrence Technological University
BME 3113 "Wearable Technology Studio"
Project 3 Grading Rubric

Names ____________________ Company Name:

Assignment Details					
Criteria	Does Not Meet Expectations	Meets Expectations	Exceed Expectations	Points	Score
"Kickstarter" Webpage					
Disruptive Technology Concept	Poor quality, lack of details.	Inconsistent quality, some details.	Highly disruptive idea with well developed functions.	10	
Brainstorming Ideas/Specifications	Incomplete, little effort.	Good effort, mostly complete.	Clear ideas and reflection.	5	
Describe the value propositions and need statement for this system.	Inadequate description of product and users.	Some description of product and users.	Detailed description of product and users.	10	
Artificial Intelligence Design	Poor quality, lack of details.	Inconsistent quality, some details.	Clear inputs, outputs and training data.	15	
Data Analytics Design	Poor quality, lack of details.	Inconsistent quality, some details.	Clear usability, appropriate data processing and graphics.	10	
Software Design	Poor quality, lack of details.	Inconsistent quality, some details.	Clear interface, and appropriate logic.	15	
Privacy and Security	Poor quality, lack of details.	Inconsistent quality, some details.	User data defined and protected with user controls.	10	
Manufacturing and Commercialization	Details confusing and gaps in the required components/specifications.	Some consideration of the production and commercialization.	Production and commercialization plans specified.	10	
Form Factor/Product Design	Poor quality, lack of details.	Inconsistent quality, some details.	Final design organized and well-explained.	10	
Lessons Learned/Future Work	Little reflection on work or strengths/weaknesses. Implications are ignored.	Some reflection and implications are discussed. Continuation work is identified.	Strengths/weaknesses stated. Implications of work are discussed. Suggested improvements.	5	
Final Presentation on Dec 14					
Pitch Video	Idea confusing and gaps in the concept details.	Some illustration of concept. Quality fair.	Illustrated idea and operation of the product. Engaging with good quality.	25	
Final Pitch Presentation	Incomplete, little effort.	Good effort, mostly complete.	Highly motivated, detailed. Engaging and organized.	20	
Presentation Slides	Confusing and gaps in the details.	Some illustration of concept. Quality fair.	Good quality with highly detailed features.	15	
Management/ Execution	Very little effort put into the project.	Good work ethic, team-effort.	Highly motivated. Good distribution of work.	15	

Total (175 pts) _________

Specific Comments