Work-in-Progress: Development of an Interdisciplinary MOOC that Introduces the NAE Grand Challenges for Engineering

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Dr. Haolin Zhu earned her BEng in Engineering Mechanics from Shanghai Jiao Tong University and her Ph.D. in Theoretical and Applied Mechanics from Cornell University, with a focus on computational solid mechanics. After receiving her Ph.D., Dr. Zhu joined Arizona State University as a full time Lecturer and became a part of the freshman engineering education team in the Ira A. Fulton Schools of Engineering. She currently holds the title of Senior Lecturer and is the recipient of the Fulton Outstanding Lecturer Award. She focuses on designing the curriculum and teaching in the freshman engineering program. She is also involved in the NAE Grand Challenges Scholars Program, the ASU ProMod project, the Engineering Projects in Community Service program, the Engineering Futures program, the Global Freshman Academy/Earned Admission Program, and the ASU Kern Project. Dr. Zhu also designs and teaches courses in mechanical engineering at ASU, including Statics, Mechanics of Materials, Mechanical Design, Mechanism Analysis and Design, Finite Element Analysis, etc. She was a part of the team that designed a largely team and activity based online Introduction to Engineering course. She has also co-developed two unique MOOCs, Introduction to Engineering and Perspectives on Grand Challenges for Engineering, for the Global Freshman Academy/ASU Earned Admission Program. Her Ph.D. research focuses on multi-scale multiphase modeling and numerical analysis of coupled large viscoelastic deformation and fluid transport in swelling porous materials, but she is currently interested in various topics in the field of engineering education, such as innovative teaching pedagogies for increased retention and student motivation; innovations in non-traditional delivery methods, incorporation of the Entrepreneurial Mindset in the engineering curriculum and its impact.

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Amy Trowbridge is a Senior Lecturer in the Ira A. Fulton Schools of Engineering at Arizona State University and is the Director of the National Academy of Engineering (NAE) Grand Challenge Scholars Program (GCSP) at ASU. Through the GCSP, Amy aims to prepare students to become globally and socially aware engineers who will lead future efforts to solve the world's biggest challenges. Amy also helps new schools to develop GCSPs as part of the NAE GCSP Proposal review committee. She is also actively involved in the Kern Entrepreneurial Engineering Network (KEEN), focused on students' development of entrepreneurial mindset through GCSP and curriculum. Amy recently received the 2019 KEEN Rising Star award for her efforts in encouraging students to develop an entrepreneurial mindset. Amy has contributed to the development of a new hands-on multidisciplinary introduction to engineering course and a unique introduction to engineering MOOC. She is interested in curricular and co-curricular experiences that broaden students' perspectives and enhance student learning, and values students' use of Digital Portfolios to reflect on and showcase their accomplishments. Amy earned her Master's degree in Biomedical Engineering from Arizona State University (ASU), and is currently pursuing her PhD in Engineering Education Systems and Design.

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Jill Roter is a senior instructional design specialist at EdPlus @ Arizona State University, where she works on complex course design projects to make college credit available for students worldwide, and provide a pathway for admission to the university. With more than twenty years experience at the intersection of digital learning, content development, and accessibility, her work reflects her commitment to identifying, evaluating, and implementing new avenues for teaching and learning, regardless of ability. Her previous roles have ranged from online producer and editor to educator and administrator in support of faculty, writers, students, and veterans at organizations such as WNET/Thirteen, Macworld Magazine, the VA, Columbia University, NYU, and CUNY. She holds a master's in special education with an emphasis on orientation and mobility (a division of rehabilitation for persons who are blind or visually impaired) from San Francisco State University.

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Abstract

This Work-in-Progress paper describes the development of an interdisciplinary course, Perspectives on Grand Challenges for Engineering, for the Massive Open Online Course (MOOC) environment, specifically for Arizona State University's (ASU) Earned Admission program. The Earned Admission initiative is the first, and currently the only one of its kind, which makes college credit available at scale, worldwide. It also provides a pathway to admission to the university for students who may not otherwise qualify. The MOOC explores the National Academy of Engineering (NAE)'s Grand Challenges for Engineering and related global challenges. This course, based on an on-ground counterpart offered at ASU, is designed to also help students develop the necessary interdisciplinary systems perspective and entrepreneurial mindset to solve the complex global challenges presented. This course fuses engineering with the social sciences, asking students to explore the interactions between society and technology, including the influences of human behavior, culture, economics, ethics, and policy on the development and implementation of technologies. The on-ground version is currently offered to engineering students in the NAE Grand Challenges Scholars Program (GCSP) at ASU.

Developing this MOOC involved reimagining and redesigning the face-to-face active learning, discussion-based course to address the instructional challenges and opportunities presented by a broader, online audience. It offers numerous ways for students to actively explore the challenges and related, cutting-edge research efforts from an interdisciplinary perspective. This online version includes interactive activities, discussions, expert talks, an open-ended project, creation of a professional digital portfolio, and a research assignment. Students also identify the competencies, skills, and/or mindset that is needed to tackle the challenges, reflect on their interests and goals, and determine the next steps they will take toward achieving them. They start their professional digital portfolio at the beginning of the course and use it to document, reflect on, and showcase their learning and accomplishments as they progress through the material. The course was first offered during session A of the spring 2020 semester, with a total of 248 students from 11 countries or regions enrolled.

This paper will describe the course goals, structure, and design, focusing on the aforementioned fusion of engineering with fields outside the discipline, which helps cultivate a systems perspective of the Grand Challenges and the engineering solutions that address them. It will also include insights gained from its design, development, and initial offering, and offer recommendations for future work.

Introduction

Many institutions across the United States, and internationally, have established an NAE Grand Challenges Scholars Program (GCSP), which aims to prepare engineering graduates not only with technical skills, but also with social skills and global awareness. Students in this program engage in various curricular, co-curricular, and extracurricular activities, all focused on an overarching Grand Challenges theme, to help them achieve the following five competencies: (1) Talent competency; (2) Multidisciplinary competency; (3) Viable business/Entrepreneurship competency; (4) Multicultural competency; and (5) Social Consciousness competency [1]. At ASU, a Perspectives on Grand Challenges for Engineering course is offered to engineering students in the GCSP, to help them develop an interdisciplinary perspective on the Grand Challenges, identify and explore their interests, and develop a preliminary plan for their GCSP study. The majority of these GCSP students take this course in their first year, and it is the first of the two requirements to achieve the GCSP's multidisciplinary competency.

As a part of the authors' work with the Kern Entrepreneurial Engineering Network (KEEN), an online version of this course was developed for the MOOC environment, offered through ASU's Earned Admission program, a program that offers both college credit at scale, and a chance for students to earn admission into ASU by successfully completing a prescribed number of courses and earning a prescribed grade point average. Students pay a small fee and verify their identity to upgrade from the Audit Track to the Credit Eligible Track. These students can obtain official university credit from ASU once they successfully complete this course with a C or better.

There was a concerted effort during the course development process to make the material modular, so that content and/or activities could be shared and used for other purposes both within the university and at other institutions. While the course modules are interrelated, they can also stand alone. These modules can be adopted and adapted by other instructors, and integrated into their own courses and/or GCSP, to reach an even broader audience.

The on-ground version of this course uses a lot of active learning techniques and is discussion-based, incorporating activities such as mind mapping, debates, role-play-based simulation, design challenges, and case studies, to help students explore and understand the interdisciplinary nature of the complex global challenges. Additional detail on the on-ground version of the course can be found in [2]. This high level of in-person, active learning posed the biggest challenge to translate to the MOOC. Therefore, in addition to reaping the benefit of modularization for portability, there was also a strong focus and intent on making the course as interactive and engaging for students in the online environment as it is on-ground. The following sections will discuss the goals of this MOOC, course design and structure, and lessons learned during its development and initial implementation.

Course Description

This 7.5-week, 3-credit MOOC, Perspectives on Grand Challenges for Engineering, introduces global challenges related to the four themes represented in the NAE's 21st century engineering vision: "Continuation of life on the planet, making our world more sustainable, secure, healthy, and joyful" [3]. It provides students with the opportunity to develop an understanding of local and global challenges within each of the Grand Challenges theme areas (Sustainability, Health, Security, and Joy of Living), and to learn about how engineers are trying to address those challenges. The course also aims to equip students with an entrepreneurial mindset that complements a technical engineering skill set and drives innovation. It helps to increase students' awareness of the social complexities involved in meeting the needs of local and global challenges through engineering and technology. In this course, students actively consider and evaluate the reciprocal relationship between engineering solutions or technologies and various aspects of society including economics, politics, environment, culture, and human behavior. The course enables students to take their first step toward becoming a well-rounded engineer, making a Grand Challenges area their life's passion, and tackling tough problems at both national and local levels. This course counts toward the Social Behavioral (SB) General studies course requirements at ASU.

The specific course objectives are to

- develop an interdisciplinary understanding of the global engineering Grand Challenges that human societies face in the 21st century;
- describe the NAE Grand Challenges themes, and learn about ongoing research in all Grand Challenges theme areas;
- identify opportunities to create added value in the Grand Challenges areas, and apply customer-focused design and an entrepreneurial mindset to conceptualize a potential future solution;
- interpret why (and in what ways) a technology or design solution adds value from multiple perspectives (technological, sociocultural, economic, environmental, global, etc.), and describe a design solution in terms of its societal value (as well as its technical features and function); and
- demonstrate an awareness of societal issues (e.g., sociocultural, political, economic, environmental, etc.) that influence and/or constrain engineering solutions.

The development team took a multimodal approach, employing various activities and assessments to help students examine the social, cultural, political, economic, ethical, and environmental factors that could affect the development and implementation of new technologies to address the challenges. Activities and discussions facilitate active learning and peer-to-peer interaction in the online environment. Expert talks feature faculty members from various institutions and industry professionals discussing their research and industry related-work around

specific challenges within each theme and promote deeper understanding of the issues. Throughout the course, students also work on a project involving entrepreneurially-minded learning (EML). They identify an opportunity to create value related to one or more of the four themes; perform customer discovery and needs analysis; imagine and develop a futuristic solution to address the needs; identify and research current technologies, which, when further developed, could enable the development and implementation of their futuristic solution; and, lastly, consider the societal implications of their solution if it were developed and implemented. To wrap up the course, students determine desired competencies needed to tackle the challenges, reflect on their own personal interests and goals, and define the next steps they plan to take toward achieving their goals.

Course Structure, Sequence, and Scope

The course design team included two faculty members who have been involved in the development and instruction of the on-ground version, along with a team of 1 lead instructional designer; 2 instructional design associates; a project manager, 2 media producers; a design ops strategist; a full stack web and data engineer assistant; a multimedia developer; and 1 manager of online learning. Operating within approximately a year-long timeframe, the faculty members applied an entrepreneurial mindset and customer-focused process to design and develop this course. They conducted interviews with directors of GCSP from other institutions to learn about their needs and gain insight into their experiences with GCSP to maximize the impact of this MOOC.

The course structure, sequence, and scope was defined based on the information gathered during customer discovery, consideration of the structure of the on-ground course, and the overarching, curricular goals. Eight modules were identified, and specific subtopics within each module were determined. The overall structure of the course is outlined in the table in Appendix A.

Module 0 presents an overview of the course, along with discussion about the value of professional portfolios. In this module, students also create and set up their own digital portfolio, using a free website development platform called Weebly. Module 1 introduces the NAE's 21st century engineering vision and provides an overview of the global challenges facing society today. It also introduces students to the interdisciplinary systems approach and entrepreneurial mindset required to address these complex challenges.

Modules 2 through 5 each center on one of the four Grand Challenges themes: Sustainability, Health, Security, and Joy of Living. These four modules have the same general structure; each one first introduces the theme, and then explores specific challenges and solutions in three related areas. The sustainability and health-themed modules discuss specific challenges and solutions in developing communities, developed communities, and globally. This helps students

to see similarities and differences between the challenges and solutions both at different scales and within different types of communities. In the security-themed module, students explore specific challenges and solutions at a personal level (focused on information security), at a national level, and, again, at a global scale. The joy of living theme area covers a wide range of topics, and is closely related to the other three themes. This module introduces three areas to provide relevant examples: education, joy of living (focused on advanced technologies), and engineering the tools of scientific discovery and exploration.

Module 6 addresses the importance of considering societal impact from multiple perspectives, and includes approaches for analyzing and/or predicting the societal impact of technology. And lastly, module 7 wraps up the course by providing students with opportunities to identify and discuss the desired competencies, skills, and/or mindset that is needed to tackle the challenges, and to start considering how they might work to achieve these competencies. The last module listed in the table in Appendix A is a repository for all material related to the course project, the Future Solutions project. Students work on this project throughout the course, and are introduced to relevant material for each of the project stages within the other course modules.

Once the course structure and specific topics had been identified, specific course content, activities, and discussions were designed and developed. Faculty course designers did not see themselves as experts on each of the Grand Challenges theme areas or the topics within them, therefore, they turned their attention to student engagement, developing content, employing various interactive tools, and writing activities to facilitate active learning and exploration of the subject matter. The course videos, graded activities and discussions, Future Solutions project, research, and professional digital portfolio are each discussed below.

Videos

Video material, demonstrating and explaining fundamental concepts, is included in each subtopic within all the modules. All videos are transcribed, and the transcripts are available to students for download. In addition to instructor-led video lectures, five application videos were scripted and recorded using voiceover animation, video clips, and/or static images to introduce concepts in a meaningful way. The first application video in the course provides a holistic view of the global challenges, and, similarly, each of the four remaining application videos broadly introduces the challenges and related engineering solutions for a given theme. The screenshots below show some of the imagery and animation from these application videos.

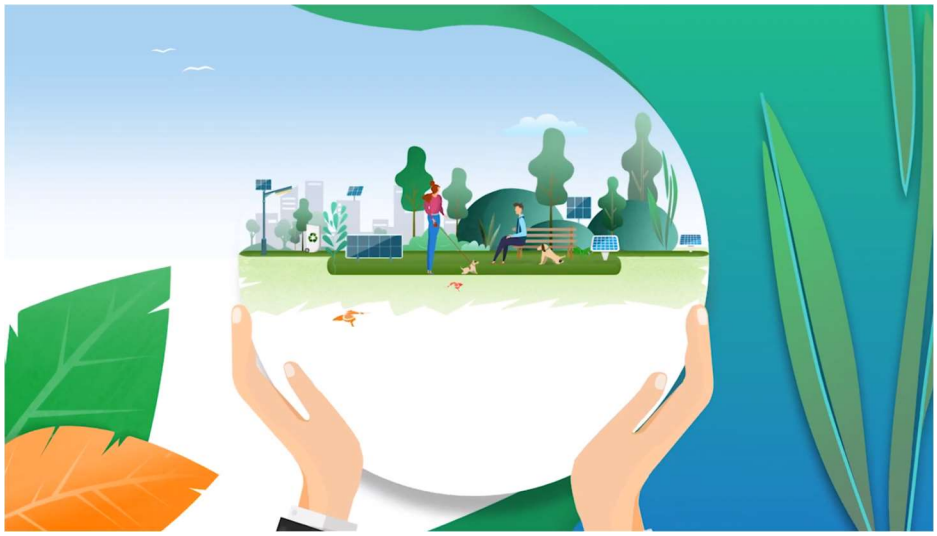

Fig. 1. Screenshot of an animation-based application video on global challenges facing society in the 21st century

Fig. 2. Screenshot of an animation-based application video, “What is Sustainability?”

The course also includes expert talks, which feature research faculty members and industry professionals from across the nation discussing the challenges in their fields and their current research and industry-related work to address some of them. Video interviews on course-related topics were also conducted with various experts and GCSP alumni. These interviews were then edited into topical video montages, providing students with multiple points of view. For example, in one such montage, the interviewees offered their thoughts on what is required to address global challenges within their fields. Another, exclusively with GCSP alumni, gave students a peer-to-peer assessment of the value of digital portfolios beyond the life of the course.

Graded Activities and Discussions

A total of 15 graded activities were designed, developed and implemented to help students apply the concepts and ideas introduced in the lecture videos and to explore more specific challenges and solutions in the theme areas. These activities incorporated a wide range of active-learning techniques for the online environment across numerous topics. They offer a medium for students to learn about the interdisciplinary nature of the challenges and possible solutions in various areas. The activities were carefully thought out, such that each one focuses on a different non-technical societal aspect that could influence the development and implementation of technologies. Examples of non-technical considerations explored in course activities include human behavior, economics, culture, ethics, policy, and public opinion. To promote engagement and understanding, the design team frequently incorporated interactive elements, ranging from video and drag-and-drop exercises to gamification and simulated role play.

For instance, in module 2's subtopic, "Sustainability Challenges and Solutions in Developed Communities," an energy economics game was developed, which simulates some of the conditions that contribute to economic barriers and opportunities in the energy market and, in turn, affect the popularity and use of different energy sources. In the game, students play the role of a utility, and purchase the required amount of energy from 10 different energy sources, under a variety of economic conditions. Their goal in the game is to meet the energy needs of their community, and make a profit while keeping the environment as clean as possible. Tariffs, tax credit, political conflicts, weather events, infrastructure degradation, and technology advancements are among the types of factors that affect the energy prices throughout the game. A screenshot of the game can be found in the figure below.

Fig. 3. Screenshot of the energy economics game in the sustainability-theme module

Another interactive example appears in module 3's subtopic, "National Security Challenges and Solutions." This subtopic includes a role-play-based simulation developed in-house, which takes students through a national security-related scenario. Students play the role of a governor who makes a series of decisions about the actions they would take in response to a security threat affecting multiple states. As students make decisions, they factor in interactions between engineers, businesses, local, state, and national government, humanitarian aid organizations, media, citizens, and others that are necessary not only to detect and mitigate the current threat situation but also to prevent possible future threats. Each decision comes with potential risks and leads to a different consequence, which also impacts their public approval rating. Through this simulation activity, students have the opportunity to explore the roles that engineers play, and recognize how engineers must connect and work cooperatively with many other people, organizations, and institutions to ensure the security of citizens and communities. Figures 4 and 5 illustrate one decision point and one consequence following a decision that appears in the simulation.

Fig. 4. Screenshot of one decision point in the role-play-based simulation in the security-theme module

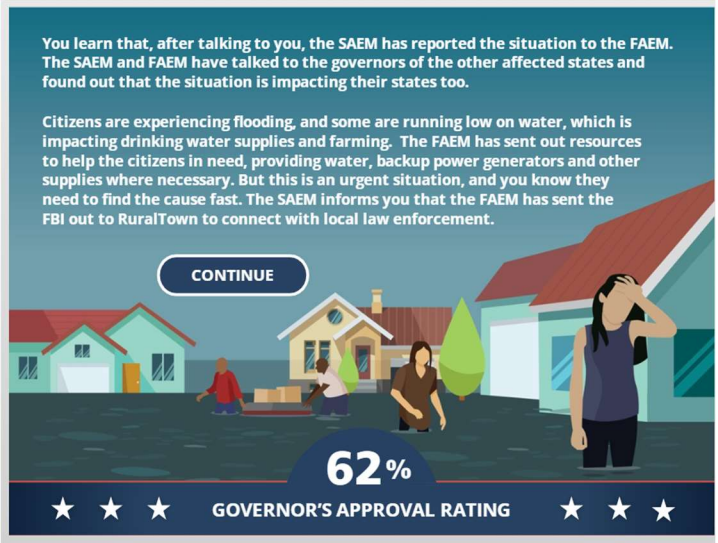

Fig. 5. Screenshot of the consequence of a decision in the role-play-based simulation in the security-theme module

There are also other types of graded activities included in the course, including, but not limited to mind mapping activities; ranking the importance of nanotechnologies from a particular character's point of view; case studies; a debate about advanced health technologies; design and redesign of a solution for a low-resource setting; pros and cons lists; and science fiction prototyping.

To encourage reflection, peer-to-peer interaction, and discussion, 24 graded discussions were integrated into the course, and students contribute via the Yellowdig platform. Fifteen of these graded discussions are associated with a respective graded activity to give students a forum to share their work and insights they gained by completing it. The remainder of the graded discussions engage students in various topics related to the theme areas such as sustainable production and consumption, climate change as a security challenge, what contributes to a more joyful life, etc. To encourage conversation, these graded discussions require both an initial post and at least one comment to other posts. Students are often asked to include screenshots in the discussion prompt instructions, and are always invited to use audio, video, and web links, and images, making for a rich learning experience.

Future Solutions Project

The Future Solutions project invites students to find their passion, exercise their entrepreneurial mindset, and develop a future solution to fulfill a need or opportunity related to the NAE's vision for engineering in the 21st century. In this open-ended project, students identify an opportunity to create added value for society, develop a futuristic solution, and research current technologies and trends to show that their solution will be technically feasible in the future. Students also

consider various nontechnical aspects such as social, cultural, global, legal, economic, and political factors when developing their solution. When considering these societal factors, they identify the challenges they may face in developing and implementing a solution that will be technically feasible and economically viable while also creating value for society. They are also asked to imagine the impact their solutions would have on society if they were to be developed. Students work on the project throughout the course, completing weekly project assignments as they work through different phases of the design process including needs analysis, solution development, exploring technical feasibility, and considering societal challenges and impact. They showcase their project work in a poster at the end of the course.

Research

After students have been exposed to all four theme areas, they are asked to examine a specific area of interest in detail in a research assignment toward the end of the course. In this assignment, students identify and research two specific examples of current research work that address the challenges in the theme area they are most interested in. They learn about the technical details of each research work example, and consider the potential societal impact of that work. They share their findings with the class in the form of a slide deck with speaker notes, so others can learn about these research work examples.

Professional Digital Portfolio

Students are also asked to reflect on their learning, connect their knowledge and experiences, infuse that knowledge and experience with meaning, and intertwine it with their own personal identities, interests, and values in a professional portfolio throughout the course. The portfolio reflections are included to help students to make sense of their learning in this fast-paced, dynamic, active learning, discussion-based, guided self-exploratory course experience. Using the free version of the website building tool, Weebly, students create and contribute to a professional portfolio, not only to showcase their current and future work, but also to reflect on and assimilate what they are learning into their everyday lives. An instructor-led lecture and a GCSP alumni montage in the very first module helps students to recognize the value of creating a professional portfolio from the outset. There are reflection assignments on each of the 4 themes, where students discuss 3 main “takeaways,” and how what they have learned has impacted their perceptions, knowledge, interests, and goals. These 4 assignments are bookended by the creation of a brief bio, or “About Me” section, and a presentation of their accomplishments in this course including the Future Solutions project and findings from their research assignment.

Assignments and Grading

Students in the course are either on the Credit Eligible Track or Audit Track. Students on the Audit Track self assess all their assignments. The graded activities for students on the Credit Eligible Track are also self-assessed, while all other assignments are staff assessed for these students. The grade breakdown for all assessments appears in the table below.

Table 1. Grade breakdown for the graded assignments

Item (# of assignments)	Weight
Graded Activities (15)	30%
Graded Discussions (24)	24%
Future Solutions Project (5)	25%
Digital Portfolio (5)	15%
Research (1)	6%

Course Implementation

The course launched in session A of the spring 2020 semester, with a total of 248 students from 11 countries or regions enrolled, 148 of whom are on the Credit Eligible Track. These learners range in age from 14 to 68, and come from a variety of educational backgrounds including students still in high school, recent high school graduates, those with some recent college experience, learners returning to school after a long absence, those looking to transfer credit to their home institution, and those taking the course for personal enrichment. These learners also have diverse academic interests, ranging from engineering to humanities, social sciences, natural sciences, and applied sciences. By the end of the second week, 154 learners were active. The highest number of submissions received for an assignment in the first two weeks was 69 (slightly less than 50% of students on the Credit Eligible Track).

Apart from their goal of earning college credit and/or admission to the university, these learners also had a variety of other reasons for enrolling in the course. Learners' interests range from expanding their knowledge to advancing their career; from learning about engineering and the Grand Challenges to learning new and creative ways to implement business ideas in the real world; from gaining insights on effectively innovating for their customers to developing an entrepreneurial mindset and becoming a well-rounded person. Some also enroll in the course out of personal interest and passion, looking to discover new ways to make a positive impact on the world.

Lessons Learned

The course designers learned a lot and gained many new insights about the course and online learning throughout the design and development of this interdisciplinary MOOC. Re-envisioning the active, discussion-based on-ground course for an online environment was a challenge that presented many opportunities for pedagogical innovation. Some elements of the on-ground course, such as class discussions and digital portfolio reflections were easily reproduced in the online environment, using appropriate tools (e.g., discussion boards, website creation tools), while others such as role-play-based activities had to be re-imagined and created in a new medium to work effectively. The biggest challenge for re-creating the active learning environment online centers on inspiring and maintaining student engagement and peer-to-peer interaction. Although games, interactives, and videos can be created to engage students in content, encouraging students to actively participate in meaningful discussions with their peers in an asynchronous, online learning environment is difficult. During the facilitation of the initial offering of this course, the faculty course design team learned that they must actively monitor the discussion boards on a regular basis in order to promote effective interaction between students.

Redesigning this course for the MOOC environment provided the course designers with a great opportunity to re-evaluate its on-ground counterpart as well. Early in the development process, the course designers were forced to take a closer look at course learning outcomes and content to ensure they were still important and relevant to the goals of the course. In many cases, when creating the content for the MOOC, new content was developed and/or significant modifications were made to existing content, often improving upon and/or updating what existed previously in the on-ground course. The course designers found these new activity modifications and concepts presented in the MOOC to be more interesting, relevant, and/or engaging for students, and thus also integrated them into the on-ground version of the course. Through the design and development of this MOOC, the course designers not only created a brand-new MOOC, but also made, and will continue to make further improvements to the on-ground course.

Conclusion and Future Work

This paper documented the design and development of a MOOC, Perspectives on Grand Challenges for Engineering. Specific course goals, structure, and content was described; insights gained as well as lessons learned from the development and initial offering of the course were also shared. This course focuses on the intersection between engineering and topics in other fields, such as public policy, economics, ethics, culture, and human behavior. Through participation in various types of activities and assignments, students develop an interdisciplinary systems perspective of the Grand Challenges, and the engineering solutions that address them. Students also develop and apply an entrepreneurial mindset, helping them to approach the world with curiosity and identify opportunities to create value for society.

Through the process of designing, developing, and delivering this course, the instructors have gained new insights, which have positively influenced the on-ground version of this course as well. Based on the insights gained from the design and development of the MOOC and facilitation of its initial offering, many improvements have been made to its on-ground counterpart to increase student engagement and enhance their learning.

Future work includes finalizing development of an online platform for sharing these course modules with the broader GCSP and engineering education community, so that they can be used to educate more students through other courses and experiences. After the first implementation of the course is complete, student performance and course evaluations will also be examined to further assess the success and impact of this course, and any necessary improvements will be made for the future. Additional research studies may also be conducted to further investigate how students' experience and learning in this MOOC compares to that of students in the on-ground course.

References

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[2] A. K. Trowbridge and H. Zhu, "Work in Progress: An Interdisciplinary Course Designed to Assist First-Year Students in Planning and Preparing for Success in the NAE Grand Challenge Scholars Program," presented at the American Society of Engineering Education Annual Conference, Columbus, OH, USA, June 25-28, 2017, Paper ID #19563.

[3] C.D. Mote, Jr., Realizing the vision of the Grand Challenges for Engineering depends on the Grand Challenges Scholars Program, 53rd National Academy of Engineering annual meeting, Oct 8, 2017. [Online] Retrieved from https://www.nae.edu/175289/Realizing-the-Vision-of-the-Grand-Challenges-for-Engineering-Depends-on-the-Grand-Challenges-Scholars-Program.

Appendix A. Overall Course Structure

The table below shows the overall structure of the course, including a list of modules, topics, and subtopics.

Table A1. Overall Structure of the Course

Module	Topic	SubTopics
0	Course Overview and Professional Portfolio	Course Overview
		Professional Portfolio
1	Goals for Engineering in the 21st Century in an Interdisciplinary, Global Context	Vision for Engineering and Specific Goals
		Developing Solutions to Interdisciplinary Societal Challenges
		Customer Discovery, Needs Analysis, and Opportunity Identification
		Introduction to the Future Solutions Project
2	Developing Solutions to Make Our Lives More Sustainable	Introduction to Sustainability
		Sustainability Challenges and Solutions in Developing Communities
		Sustainability Challenges and Solutions in Developed Communities
		Global Sustainability Challenges
3	Developing Solutions to Make Our Lives Healthier	Introduction to Health
		Global Differences in Health
		Health Challenges and Solutions in Developed Communities
		Health Challenges and Solutions in Developing Communities

4	Developing Solutions to Make Our Lives More Secure	Introduction to Security
		Personal Security Challenges and Solutions
		National Security Challenges and Solutions
		Global Security Challenges and Solutions
5	Developing Solutions to Make Our Lives More Joyful	Introduction to Joy of Living
		Education-Related Challenges and Solutions
		Challenges and Solutions in Joy of Living
		Challenges and Solutions Related to Engineering the Tools of Scientific Discovery and Exploration
6	Impact of Engineering Solutions	Societal Impact of Technology Frameworks
7	How Can You Make an Impact?	Realizing the Goals for Engineering in the 21st Century: Competencies
		Taking Action
		Moving Forward with What You have Learned
Project	Future Solutions Project	Project Description
		Needs Analysis Part 1
		Needs Analysis Part 2
		Developing a Solution
		Identifying Technology Development Milestones
		Future Solutions Project Poster