Strategic Design of an Introductory Engineering Management Course for Active and Flexible Hybrid Delivery

Kellie Grasman, Missouri University of Science and Technology

Kellie Grasman serves as an instructor in Engineering Management and Systems Engineering at Missouri University of Science and Technology. She holds graduate degrees in engineering and business administration from the University of Michigan, and began teaching in 2001 after spending several years in industry positions. She was named the 2011-2012 Robert B. Koplar Professor of Engineering Management for her achievements in online learning. She serves as an eMentor for the University of Missouri System and earned a Faculty Achievement Award for teaching.

Dr. Suzanna Long, Missouri University of Science and Technology

Dr. Suzanna Long is Professor and Department Chair of Engineering Management and Systems Engineering (EMSE) at Missouri S&T and holds a Ph.D. and M.S. in engineering management, B.S. in physics and in history (University of Missouri-Rolla) and an M.A. in history (University of Missouri-St. Louis). Her research focuses on critical infrastructure systems, including sustainability in global supply chains, energy, and transportation systems. She is a recognized expert in sociotechnical systems. She is a Fellow of the IISE and the ASEM

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Abstract

Given the ongoing need to deliver high quality instruction during a period of great disruption and uncertainty, an undergraduate management course for engineers was strategically redesigned. The course reaches nearly 100 students per semester and is traditionally delivered in a classroom-based lecture format. To accommodate student participation preferences, mandatory classroom capacity limitations, extended health-related absences, and other considerations unique to delivery in a pandemic, the course was redesigned for hybrid delivery.

Course redesign was informed by analysis of the instructional environment, student surveys of participation and learning design preferences, early findings from studies of Spring 2020 emergency remote teaching, proven active learning strategies, and quality online/hybrid design standards. The resultant design offers students a choice of classroom or virtual participation based on their needs and preferences, and an opportunity to shift participation mode if circumstances require. Course activities include content presented in multiple, accessible modes, active practice with concepts and terms, cases completed in teams, activities linking fundamental concepts to practical applications, and frequent summative assessment.

Initial course delivery offered an opportunity to refine the course design throughout the semester based on instructor observations, formal and informal student feedback, and changing environmental conditions. End of course surveys and assessment data were used to evaluate instructional effectiveness and inform future iterations of the course design.

Introduction & Instructional Context

After the initial emergency shift to remote learning in March 2020 due to the global Covid-19 pandemic, careful preparation for future semesters of continued uncertainty and disruption became a necessity. Beginning in Summer 2020, planning for the Fall 2020 semester began in earnest. An undergraduate course, Engineering Management 2110 – Managing Engineering and Technology, at Missouri University of Science and Technology in the department of Engineering Management and Systems Engineering was redesigned to meet campus requirements while satisfying student needs and preferences.

The required undergraduate-level Managing Engineering and Technology survey course serves in-department students majoring in Engineering Management, as well as students from various other engineering disciplines as part of a minor in Engineering Management. Typical course composition includes approximately 50% sophomore and 50% junior standing students. The three-credit course does not have any prerequisites but is required to be completed in advance of higher-level courses by students pursuing a degree in Engineering Management. The course is typically offered in fall and spring semesters with enrollment of approximately 90 students each semester. The course exists to introduce the management functions of planning, organizing,

motivating, and controlling. Further, the course analyzes the application of these functions in research, design, production, technical marketing, and project management and studies the evolution of the engineering career and the transition to engineering management.

The course was regularly delivered in a traditional format with two 75-minute classroom sessions each week, including lecture by the instructor with student response to questions using clickers. Assessment typically involved individual assignments and several multiple-choice exams each semester. This course format had been refined over multiple semesters and was generally well-received by students.

The authors of this paper began preparations to co-teach the course for a large section of 90+ students in Fall 2020. Throughout Summer 2020 they explored student participation preferences, mandatory classroom capacity limitations, prevalence of extended health-related absences, and other considerations unique to course delivery in a pandemic. The sections that follow outline the factors influencing the resultant active and flexible hybrid delivery model, as well as outcomes from Fall 2020 and adaptations for future semesters.

Survey to Inform Course Design

Course redesign was informed by analysis of the instructional environment, student surveys of participation and learning design preferences, early findings from studies of Spring 2020 emergency remote teaching, proven active learning strategies, and quality online/hybrid design standards. The analysis of such factors is presented in this section.

At the time of course planning, the campus instructional environment for the Fall 2020 semester remained constrained by health and safety guidelines. Many courses were scheduled to be offered fully online and those that were not fully online needed to accommodate students who were unable or unwilling to come to campus. In other words, courses meeting in a classroom also had to offer online access via synchronous streaming of the live class session or alternate method to reach all students – both in the classroom and online. This delivery method is typically termed Hy-Flex and is an instructional approach very familiar to one of the authors. The course was assigned a classroom with a standard capacity of 100 students, but distancing restrictions in place for the semester required that no more than 25 students participate in the physical classroom at one time. Therefore, if students were scheduled to attend alternately in person, each student would be able to attend one in-person class session every two weeks (equating to approximately seven total per semester). Further, all students and faculty entering the classroom were required to always wear masks and maintain a distance of at least six feet from one another.

Given the classroom limitations outlined above, coupled with a desire to match instructional design to student participation preferences, the instructors surveyed students in advance of the semester. Specifically, instructors wanted to anticipate student demand for classroom vs virtual participation to optimize the learning environment given the constraints in place. Further, the survey provided an opportunity to explore student perceptions of course activities and assess student access to technology. The survey was distributed in early August to all enrolled students via email. Students accessed a Qualtrics survey via a link in the email and had the option to

submit responses anonymously or include their contact info so instructors could follow up personally with individuals. The response rate to this optional, pre-semester survey was 56%.

Responses to select questions are summarized here:

Table 1: In general, how comfortable are you returning to campus for the Fall 2020 semester?

Answer	%	Count
Extremely comfortable	28.00%	14
Comfortable	26.00%	13
Neither comfortable nor uncomfortable	12.00%	6
Uncomfortable	30.00%	15
Extremely uncomfortable	4.00%	2

Table 2: Specifically, how comfortable are you returning to regular class meetings in our physical classroom? (FYI: The assigned room is a large lecture hall with 100+ seats; distancing requirements will limit attendance to 25 students per session, all campus protocols will be enforced.)

Answer	%	Count
Extremely comfortable	26.00%	13
Comfortable	38.00%	19
Neither comfortable nor uncomfortable	14.00%	7
Uncomfortable	16.00%	8
Extremely uncomfortable	6.00%	3

Table 3: This course will involve a variety of learning activities including readings, assignments, case discussions, lectures, exams, and more. Due to environmental factors, the course will be structured such that physical presence in the assigned classroom will not be required. In-person participation is encouraged for those who are comfortable meeting in the classroom, but there will be no penalty or disadvantage for participating in a fully remote fashion. Given what you know now, how would you classify your intent for the fall semester? [Recall, we are using this info for planning purposes only. Your response does not bind you any action.]

Answer	%	Count
Intend to participate 100% remotely - no physical classroom desired	26.53%	13
Intend to participate in physical classroom - as often as possible	53.06%	26
Need more information to make a decision	20.41%	10

Table 4: Your instructors will offer an engaging learning environment, no matter how you choose to participate. While we cannot accommodate each individual's specific preferences, you will have some choices. Recall the course is titled: Managing Engineering and Technology. It involves new terminology and concepts, and application of those concepts to practical business scenarios. Please rank the following learning activities in order of preference (where 1 is the most desirable activity).

Learning Activity	Avg Rank	Min:Max	Std Dev
Discussing a business case/scenario	3.71	1:10	2.75
Interactive activities in the physical classroom (i.e., small group discussion)	4.81	1:10	2.74
Watching a live lecture in the physical classroom	5.38	1:11	3.43
Practicing with conceptual questions about terms and ideas	5.54	1:11	2.27
Watching pre-recorded lecture videos organized by subject (3-8 minutes)	5.58	1:11	3.37
Watching a live lecture in a virtual Zoom classroom	5.63	1:11	3.13
Watching a news video and discussing	5.63	2:11	2.75
Practicing with quantitative analysis questions	6.46	1:11	2.82
Interactive activities in a virtual Zoom classroom (i.e., small group discission)	6.79	2:11	2.74
Researching a specific topic of interest	7.33	1:11	2.73
Reading a textbook	9.15	4:11	2.19

Table 5: Which of the following tool(s) will you have reliable access to participate in online activities?

Answer	% w/access
Laptop	100%
Mobile phone	100%
Reliable highspeed Internet access	82%
Webcam	68%
Headset/headphones + microphone	80%

Overall, the survey responses highlighted three important factors to be considered in the instructional design. First, while slightly more than half of respondents intended to participate in the classroom, a significant portion were not comfortable meeting in person and consequently instructional design must accommodate these varied needs. Further, though not captured in the survey, periodic need to quarantine or isolate may disrupt in-person attendance. Second, while student activity preferences did not directly dictate course design, it was helpful to understand what students generally enjoy and dislike. Reading the text is not popular; business cases and

interactive activities are desirable. Third, respondents reported reliable access to devices but interactive tools like webcams and headsets should not be expected of all students.

In addition to multiple choice questions, students were presented a text-entry area to share additional questions or concerns with the instructors. The general theme of comments included gratitude for the effort to solicit student input and offer a choice of participation option. Several students shared specific concerns based on their experience in other courses during emergency remote instruction in the past semester. Instructors were able to reach out directly to individual students to better understand their concerns and plan to alleviate through careful instructional design.

Analysis to Inform Course Design

The strategies utilized to shift to online delivery for Spring 2020 primarily fell into the category of emergency remote teaching [1]. However, while the need to continue remote delivery has persisted, planning for subsequent semesters can be informed by the wealth of knowledge that has been developed over decades of study to inform quality course design and instruction for online learning [2]. In addition, consideration of the unique circumstances of learners who may continue to experience disruptions and uncertainty in their educational and personal environments is paramount [3].

One author, though experienced and formally trained in online course design and delivery, sought to update their skills and pursued multiple formal and informal learning opportunities immediately prior to developing this course. Specifically, NETI -3 Online offered an up-to-date analysis of active engagement strategies for online STEM courses [4] [5]. Recognized leaders in quality online instruction prepared comprehensive, research-based resources for online course development and delivery that provided best practice standards [6]. Additionally, while quarantined at home with three college-age offspring, the author experienced a firsthand window into the student experiences of online college learners.   These and countless other sources, combined with experience, informed the course development process.

Additionally, because up to half of students were expected to participate remotely and others would need to transition to remote temporarily throughout the semester, the course was structured to operate fully online to accommodate those students. While some students would participate in the physical classroom, all content and assessments must be accessible and appropriate for remote learners. Consequently, the course was designed to satisfy recognized standards for quality online and blended education as prescribed by the Quality Matters rubric standards [7]. The Quality Matters rubric provides standards for all course components as well as alignment of critical components to ensure student learning outcomes. A thorough treatment of this course design relative to the 41 detailed Quality Matters standards is beyond the scope of this paper.

Past teaching and course design experience, coupled with a thoughtful exploration of the unique circumstances of the COVID-19 era, informed several general themes in the course development. Specifically, the lack of a secure environment to administer high-stakes assessment led to the general approach of distributing frequent, lower-stakes authentic assessment throughout the

course. In addition, anecdotal information and early reports of the isolating impact of remote instruction and disruption of routine encountered by college students led to a need to create an opportunity for community building and regular human connection within the course. Finally, experience has shown that the management adage of "what gets measured gets done" holds true for course design as well. Activities or resources that do not have a point value are viewed as unnecessary by students. Consequently, students were presented frequent graded activities to encourage interaction with the material and time on task each week.

Resultant Instructional Design

The resultant instructional design was informed by all factors discussed previously including analysis of the instructional environment, student surveys of participation and leaning design preferences, early findings from studies of Spring 2020 emergency remote teaching, proven active learning strategies, and quality online/hybrid design standards.

The resultant design offered students a choice of classroom or virtual participation based on their needs and preferences, and an opportunity to shift participation mode if circumstances require. Course activities include content presented in multiple, accessible modes, active practice with concepts and terms, cases completed in teams, activities linking fundamental concepts to practical applications, and frequent summative assessment. The course design could be classified as a hybrid delivery, with course elements summarized below.

Practice– 15% of final grade, one per Module

Each Module will include a Practice assignment designed to help students develop proficiency with concepts and terminology in the course. Practice is completed within Canvas and involves adaptive multiple-choice questions related to specific course topics. Achieving 80% proficiency in a Practice assignment assures full credit/points. Conscientious completion of Practice within each Module is good preparation for Quizzes.

Activities – 25% of final grade, one per Module

Activities will be presented in Modules on Canvas, with specific submission dates and grading criteria/rubrics. The nature of Activities will vary, and may include self-assessments, management video analysis, data analytics assignments, and more.

Cases – 25% of final grade, one per Module
Students participating in face-to-face classroom sessions will complete case discussions with assigned teams in the classroom. Students participating fully online will complete case discussions with assigned teams via Zoom breakout rooms.   Each team member will have an assigned role (Facilitator, Recorder or Presenter) that rotates throughout the semester. Each team will submit one collaborative response to the assigned case questions and activities via Canvas for grading.

Quizzes – 35% of final grade, 4 total
Quizzes will be completed online via Canvas at regular intervals (approximately one every four modules) throughout the course. Completing Readings and viewing Lessons, along with conscientious completion of the Practice activities, will help you prepare for Quizzes. Quizzes are multiple choice, timed and allow one attempt.

All course content and graded assignments were organized into Modules presented in Canvas with a similar structure each week. Each Module consisted of an Overview (list of all items in a module), Readings and Lessons, Practice, Activity and Case. In a given week, students were tasked with reviewing Readings and Lessons in advance of their scheduled class session. Readings and Lessons included specific learning objectives with links to associated sections of the digital textbook, *Management* 14th edition by Schermerhorn and Bachrach [8]. Further, each learning objective offered a short video summarizing concepts and terms. A comprehensive set of notes in PowerPoint were provided for each Module. Additional graded work, the Practice and Activity associated with each Module, were due to submit in Canvas on Tuesday and Thursday end of day, respectively.

As the basic lesson/lecture content was delivered asynchronously through Canvas, scheduled live class sessions were utilized to facilitate interactive case discussions. Students, via online survey, selected their initial participation preference immediately prior to the beginning of the semester. At that time, 48% of students elected to participate live in the physical classroom and 52% chose live virtual participation. Due to classroom capacity limitations, students were split into teams of three students with half of the teams participating live on Tuesday, the other half live on Thursday during the scheduled course meeting time. Classroom teams gathered in a large lecture room and sat together, distanced with masks, to discuss case topics and prepare responses to assigned questions as a team. Classroom sessions were facilitated by an instructor and/or TA for the course. Students participating virtually were also split into teams, with half of the virtual teams meeting each class session (i.e., case teams met once per week). Virtual teams joined the live class session in Zoom, where topics were introduced to whole group by the instructor before teams were split out into individual breakout rooms to collaboratively discuss the case. For both classroom and virtual sessions, after teams discussed the cases within their group, all students convened together for instructor-facilitated discussion of the case. Teams submitted responses to specific case-related questions via Canvas for grading.

Implementation

While initial participation saw 48% of students participate live in the physical classroom and 52% with virtual participation, some shifts occurred throughout the semester. Several students

elected to move *permanently* from classroom to virtual participation near the beginning of the semester and self-reported a preference for the virtual experience (not health or safety reasons) for the shift. This shift was readily accommodated by creating a new virtual team for case participation. Final end-of-semester participation preferences resulted in 41% in classroom and 59% of students virtual. Most notably, a full 22% of students were forced to *temporarily* shift from classroom to virtual participation for one or more weeks due to illness, a need to quarantine/isolate, or other health-related reasons. In these cases, classroom students were added to a virtual team temporarily, then returned to the physical classroom when able. The logistics of managing shifting participation was somewhat complicated, but students overwhelmingly appreciated the option to elect their participation preference, as reflected in end of semester evaluations and comments.

One instructor observed a notable increase in quantitative evaluation of teaching effectiveness with this course, as measured by end of semester surveys administered by the university. Though there is no data for past semesters (this was the first time teaching the course in recent years for the instructor), students awarded a teaching effectiveness of 3.6 out of 4.0. The instructor's typical teaching effectiveness averages 3.2/4.0 with a campus average of 3.0 to 3.1 for all courses.

Students were encouraged to submit open-ended comments in both the standard teaching evaluation, as well as a post-semester survey administered by the instructors. Several themes appeared repeatedly in student comments and were used to inform future iterations of the course. First, students appreciated the flexibility of the course structure to simultaneously accommodate those who strongly desired an in-person experience and those who preferred virtual – while also allowing temporary shifts to virtual as necessitated. In general, many students reported they had almost all courses online that semester and appreciated the option to have a choice of participation mode. Further, students appreciated the opportunity to regularly interact with a team of classmates as an integral part of course requirements. In an otherwise often isolating semester, students appreciated the chance to engage in small groups and connect with the class via case discussion. Relative to graded components, students hoped to see more direct connections made from text content to the Activities and Cases. Also, not surprisingly, some students felt they would prefer more direct instruction rather than accessing video and notes independently. These weaknesses were addressed in the subsequent semester.

The student survey also contained the following question, eliciting student preference of course learning activities:

Table 6: This course offered classroom or virtual participation options, but all students accessed the same resources and completed the same graded work. Please rank the following learning activities in order of preference (where 1 is the most desirable activity)

Learning Activity	Avg Rank	Min:Max	Std Dev
Completing graded Cases with your team	1.69	1:7	0.91
Discussing Cases with the whole class	3.46	1:7	2.06
Completing graded Practice assignments	3.85	1:7	1.43

(multiple choice questions)			
Completing graded Activities related to the weekly topic	4.12	2:7	1.58
Completing Quizzes over text material	4.62	1:7	1.64
Watching a lecture video	4.81	1:7	1.84
Reading the textbook	5.46	1:7	1.87

As noted in the ranked list, case discussions with teams followed by debriefing with the class were most desirable. Further, more passive activities such as watching video and reading text were outranked by collaborative and interactive tasks in the course.

Conclusions

While a wholly new course design informed by detailed online/hybrid quality standards may not be appropriate for all, several transferrable lessons-learned emerged from this implementation. First, as indicated in student survey data from Table 4 and Table 6 and reinforced by open student comments, learning by actively engaging with course content and/or classmates is generally preferred over passive learning activities. Though this trend may not hold true for all audiences and course environments, it is worthwhile to consider student preferences – especially when they highlight a desire for proven active learning approaches. Due to the circumstances, the authors can make no claims related to the impact of these specific activities on the attainment of course learning outcomes, yet research generally supports active strategies.

Related to student preferences for active learning, the specific activity of case discussions with teams of classmates was identified by students as most desirable prior to beginning the course and emerged as the favorite after course completion. While many students were unfamiliar with case analysis prior to entering the course, they quickly developed proficiency in connecting basic course topics to practical real-world business and engineering scenarios though case discussions with assigned teams followed by debriefs with the whole class. Cases gave students a chance to apply the basic concepts they were learning, but most importantly, offered an avenue to regularly interact with peers. Students participating virtually and in person valued the consistent formal and informal interactions afforded by weekly case activities with their team. Undoubtably, these interactions positively impacted student perceptions of the course overall, with several students explicitly stating they really looked forward to live case sessions each week. The opportunity for human connection in an otherwise isolating time was highly valued and will likely continue to benefit students beyond the pandemic teaching era.

The authors acknowledge that allowing students to choose their preferred mode of participation added complexity to the course delivery. However, the option of choice was highly valued by students for assorted reasons. Some noted that, in a period of uncertainty, they appreciated the ability to have control over their learning environment and participate in the manner they found most comfortable or safe at the time. While students were free to move freely from in person to virtual participation, this option was never abused and the few who shifted preference during the semester did so to meet medical or safety needs. From the instructor perspective, having all course content accessible online made it simple to accommodate participation shifts in the initial

delivery. However, this structure continues to offer flexibility and accessibility for future semesters. Though remote instruction may become unnecessary, the need to accommodate brief or prolonged student absences will persist. The flexibility afforded by housing all necessary content and assessment online will continue to add value for future in-person or hybrid offerings.

Future Work

The initial pilot delivery concluded in Fall 2020 and the course was offered again in similar format in Spring 2021, with modifications informed by experience and student input. Specifically, the Spring course was scheduled in two distinct sections with one section offering traditional in-classroom lecture delivery. A second section, offered on a different schedule from the traditional delivery, followed a structure like the hybrid pilot. If their schedule allowed, students could choose between the traditional classroom and hybrid approach.

Students electing the hybrid section encountered an instructional design like that outlined previously, with some important modifications. Specifically, the course was scheduled to meet Monday, Wednesday, and Friday for 50 minutes each session with no physical classroom participation option. All students in the hybrid section joined a live lesson/lecture session on Monday via Zoom where the instructor presented basic concepts, highlighted important topics in lecture notes, inserted active learning strategies during lecture and formed associations between core content and the week's cases and activities. This added component allowed to correct for the shortcomings related to direct instruction and linkages between activities noted in the pilot. A participation grade was added to encourage attendance in live lecture sessions. During the other class meetings, students continued to work in teams on cases during live Zoom sessions with the addition of specific, rotating roles for each team member. Students alternated between acting as "facilitator", "recorder" and "presenter" within the team, and each team was expected to be prepared to present findings during the full class discussion following breakout rooms.

This modified delivery was nearing mid-semester as the paper was finalized, but early indicators suggest the approach is again well-received by students. Future offerings are expected to continue to allow students a choice of format, and the hybrid delivery will allow access for students who elect to study away from campus.   Further, quantitative comparisons of learning outcomes across formats may be explored to explicitly measure effectiveness of the flexible, active approach.

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