Instructor Experiences Teaching Model-Based Systems Engineering Online Modules to Professional Learners

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Introduction and Literature Review

In this work-in-progress paper, we examine the experiences of instructors when teaching online Model-Based Systems Engineering (MBSE) modules to professional learners. We focused on online learning modules because of their flexibility, which allows them to be used as an effective strategy for updating engineering curricula or to be used independently. Such flexibility is represented by the removal of geographical barriers in the way of educational opportunities and making course schedules more respectful of the learners' time availability [1]–[3]. When it comes to delivering educational content to professional learners, these advantages become more pronounced as they make learning adapt itself around the reality of these learners [2]. The time flexibility helps because professional learners are employed and often have other types of life responsibilities. The geographical flexibility is helpful in terms of not being limited to learning opportunities in regions close to their job. Moreover, online instruction is more sustainable and scalable [4], allowing a wider population to be served.

What is expected from the instructors in an online course is often different than in a traditional classroom. According to the Community of Inquiry (CoI) framework, meaningful online learning experiences include three main aspects: social, cognitive, and teaching presences [5]. The teaching presence refers to the instructor's ability to facilitate the other two presences in the online environment—in other words, how the instructor fosters a learning community and guides their discussions around the course content. To successfully embed teaching presence in online classrooms, instructors need to identify similarities between online learners, allow sufficient time and encouragement for online discussion and interaction, etc. [6], [7]. While it is more straightforward to do so in a face-to-face classroom, online learning relies on multiple educational technologies and media, requiring instructors to be more familiar and open to multimedia tools [8]. Research also showed that how instructors see themselves in teaching plays a role in their online teaching experience. Nkonge and Gueldenzoph [9] compared the role of online instructors as "sage on the stage" and the role of traditional class instructor as "guide on the side" to emphasize on the fact that instructors often need to take more responsibility in facilitating online interactions.

Instructor experiences in online teaching are multifaceted. Because of how flexible online modules are, some instructors may not be content experts [10], in which case additional help and resources might be needed to facilitate teaching the module. For example, Harichandran and colleagues [11], [12] studied the use of online modules designed to develop entrepreneurial thinking by non-expert instructors. These instructors were provided assistance from a subject-matter expert to help them integrate the modules into their courses. Another aspect worth

studying is instructors' prior experiences in online teaching. Choi and Park [13] examined the experience of an instructor in their first time teaching an online course and found the instructor struggled with promoting learner interactions online. Instructors' familiarity with online teaching pedagogies also shapes their experience. For instance, Roman and colleagues [14] found that creating a training program for instructors and introduce them to some online teaching pedagogies and best practices before they start teaching can bring positive outcomes. Doing so may help instructors avoid misbehaviors that negatively affect student experiences [15], [16].

By understanding the experiences of instructors of varying levels of involvement in the design of the modules and expertise in the MBSE content, this work-in-progress paper aims to provide helpful insights for other instructional designers or instructors that might teach online modules. Our team has previously designed a series of online, asynchronous modules informed by the CoI framework to respond to the industrial needs of MBSE training [17]. Our modules are designed for learners who are interested in understanding the value, functions, and offer them opportunities to apply their learning in projects. Our guiding research question is "What are the experiences like for instructors who used our pre-designed MBSE modules to teach professional learners?" We expect to use our findings to inform the general practice of using and designing online modules in the context of professional education, while also providing a more specific insight into specific challenges that MBSE instructors might face.

Methods

We conducted semi-structured interviews with four instructors who taught our modules to professional learners. Our suite of modules includes the following units: "1: Introduction to Systems Engineering (SE) and MBSE for Production Systems". "2A: Engineering a System with Systems Modeling Language (SysML)", "2B: SysML Implementation and Applications", "3: Quantitative Methods Supporting MBSE", "4: Production engineering and MBSE", "5: Digital Engineering and the Model-Based Enterprise", and "6: MBSE Capstone Project". These are designed to provide students with enough knowledge and practice to enable them to start applying MBSE in their professional environments.

The interview protocol was constructed to understand instructor experiences using the modules, the scaffoldings they provided to learners, and the effectiveness of the modules as perceived by them. All the participants in this WIP were involved in the module design process as content selectors or as content producers. Content selectors were responsible for content selection and establishing main course goals in the modules while collaborating with instructional designers on the pedagogical approach. Content producers were in charge of transferring the selected content to presentation slides and presenting the materials in the instructional videos. Some of the participants had extensive experience with the use of MBSE in industry, while others had more basic knowledge in the academic space of MBSE. More details about the participants can be seen in **Table *1***. We analyzed the interview transcripts using thematic analysis [18] and inductive

coding approach. Three researchers independently coded the interview transcripts for emerging themes. Then the researchers discussed their individual codes and agreed on a coding scheme by combining similar codes and categorizing codes into larger themes. Using the new coding theme, the researchers separately went through the transcripts once again. All three researchers reviewed the final coding until consensus was reached.

Table 1

Teaching Experience and Participation in the Design of the Modules for Our Study Participants

Participant	Module(s) taught	Module(s) designed	Involvement with module design	Previous experience with online teaching?	Position	Familiarity with MBSE content
Roger	2A, 2B, 6	2B, 6	Content production	No	Graduate student	Medium
Steven	1	1, 2A, 2B, 6	Content selection	Yes	Full-time professor	High
Bailey	5, 6	5, 6	Content production	No	Graduate student	Medium
Gerald	3, 4	3, 4	Content selection	Yes	Full-time professor	High

Preliminary Results

Based on our initial instructor interviews, themes emerged regarding factors that appeared to impact instructors' experience utilizing the online MBSE modules, which we will now explore.

Pre-conceived notions about online interactions

Our research participants had varying levels of experiences interacting with learners online. Steven was the one most familiar and comfortable facilitating student interactions via discussion forums. He set up a daily summary of online discussions while teaching the module and communicated with students regarding their expectations of the module learning goals. In contrast, two instructors, Roger and Bailey, who were graduate teaching assistants and had not taught in an online asynchronous context before expressed some frustration with the lack of personal interaction in a fully asynchronous context. Roger stated "maybe because it was online it didn't really feel hands-on. And when I say hands-on, it's more being able to see the students and being able to listen to their voices at that time and being able to provide solutions and being able to get to teach them." Both of these participants made an effort to respond to all student discussion posts: Roger appeared to be highly engaged, but Bailey was initially limited by a misunderstanding of how to use the learning management system. Gerald was the only one to

voice a more negative view of the modules, even though he reported a considerable amount of experience with distance learning. He expressed a generally skeptical attitude toward online instruction and appeared to be dubious of online instruction pedagogy. For example, he was skeptical about how much feedback learners would get from participating only in online discussion forums. Gerald also expressed doubt about whether the teaching methods in the modules would be effective, stating, "teaching a class, recording a class, delivering a class online asynchronously, and then having a quiz after each class… I don't know whether that's the most effective way".

Instructor comfort level with MBSE subject matter

Our modules are designed to be used by instructors with varying levels of familiarity with MBSE. Since some of the instructors we interviewed used modules which they themselves did not create or only produced content for, we sought to get their feedback on this aspect of the experience: teaching content which was prepared by someone else in an area outside of your expertise. Although Steven had extensive amount of experience in the field of MBSE, he still consulted with the module content designers while teaching to seek external support. Bailey, who felt less confident about their level of expertise on MBSE, similarly reported passing the more difficult or controversial discussion questions from the learners to the experts who had created the content for the module. The consensus among the instructors interviewed was that anyone not completely familiar with the content teaching the modules should have a content expert they could reach out to when needed. Furthermore, one instructor expressed some uncertainty about the pedagogical philosophy behind the design of the module they were teaching, as it had been envisioned by someone else. This suggested that providing some material explaining the pedagogical background and design choices could be helpful in orienting and preparing new instructors.

Conclusions and future work

Our preliminary interviews with the instructors who taught MBSE modules revealed emerging themes which can inform future use and successful implementation of the modules. Instructors' attitudes toward online interaction clearly impacted their experience teaching the modules. As ongoing and future work, we are continuing to analyze interviews we conducted with instructors who were not involved in the design of the modules when teaching for professional learners or as part of their undergraduate and graduate courses. These interviews should be especially informative as we investigate how to best support the deployment and implementation of the modules for a wider audience. Studying instructor experiences in these online modules will generate knowledge on how to better support instructors who want to update their courses to meet an emerging need from the industry without having to become context experts themselves. Using pre-built modules like these would be especially useful in the context of smaller higher education institutions that might not have the resources to hire specialists in fields such as MBSE

but still wish to include them in their curriculum with confidence. This enables instructors to better prepare their students to industrial needs while simultaneously allowing instructors to increase their own expertise in the process.

To be successful in using curriculum modules, instructors must be willing to try new approaches beyond what they may consider as “standard” online teaching. Akin to how published curriculum frequently provides an instructor manual, orientation material for the instructors who would implement the curriculum modules might overcome some of the challenges instructors discussed in this study. For example, it might be helpful for instructors to read a brief rationale for the pedagogical decisions made in the module and some of the research-informed practices instructors can employ to promote student interaction. Finally, to help instructors use the modules when they are not subject matter experts, providing a cheat-sheet of FAQ student questions or connecting them with a content expert to offer external support could be beneficial.

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References

[1] R. Panigrahi, P. R. Srivastava, and D. Sharma, "Online learning: Adoption, continuance, and learning outcome—A review of literature," *Int. J. Inf. Manag.*, vol. 43, pp. 1–14, Dec. 2018, doi: 10.1016/j.ijinfomgt.2018.05.005.

[2] S. Appana, "A review of benefits and limitations of online learning in the context of the student, the instructor, and the tenured faculty," *Int. J. E-Learn.*, vol. 7, no. 1, p. 5–22, 2008.

[3] Y. W. Li, N. Mai, and N. Tse-Kian, "Impact of learner-centred teaching environment with the use of multimedia-mediated learning modules in improving learning experience," *J. Teknol.*, vol. 68, no. 2, Art. no. 2, Apr. 2014, doi: 10.11113/jt.v68.2911.

[4] S. McClellan, "Teaching critical thinking skills through commonly used resources in course-embedded online modules," *Coll. Undergrad. Libr.*, vol. 23, no. 3, pp. 295–314, Jul. 2016, doi: 10.1080/10691316.2014.987416.

[5] D. R. Garrison, "Community of inquiry," in *E-learning in the 21st century: A community of inquiry framework for research and practice*, Taylor & Francis Group, 2016, p. 22–34. [Online]. Available: http://ebookcentral.proquest.com/lib/purdue/detail.action?docID=4710094

[6] R. E. Brown, "The process of community-building in distance learning classes," *J. Asynchronous Learn. Netw.*, vol. 5, no. 2, p. 18–35, 2001, doi: 10.24059/olj.v5i2.1876.

[7] T. Anderson, R. Liam, D. R. Garrison, and W. Archer, "Assessing teaching presence in a computer conferencing context," *J. Asynchronous Learn. Netw.*, vol. 5, p. 1–17, 2001.

[8] D. Howlett *et al.*, "Integration of a case-based online module into an undergraduate curriculum: What is involved and is it effective?," *E-Learn. Digit. Media*, vol. 6, no. 4, pp. 372–384, Dec. 2009, doi: 10.2304/elea.2009.6.4.372.

[9] B. Nkonge and L. E. Gueldenzoph, "Best practices in online education: Implications for policy and practice," *Bus. Educ. Dig.*, no. 15, pp. 42–53, May 2006.

[10] T. A. Fuhrmann and J. Hoth, "Interactive online learning modules for engineering students based on JiTT and PI," in *SEFI 49th Annual Conference: Blended Learning in Engineering Education: Challenging, Enlightening - and Lasting?*, Berlin, Germany, 2021, pp. 825–835.

[11] R. S. Harichandran, M.-I. Carnasciali, N. O. Erdil, C. Q. Li, J. Nocito-Gobel, and S. D. Daniels, "Developing entrepreneurial thinking in engineering students by utilizing integrated online modules," presented at the 2015 ASEE Annual Conference & Exposition, Jun. 2015, p. 26.499.1-26.499.22. Accessed: Feb. 02, 2023. [Online]. Available: https://peer.asee.org/developing-entrepreneurial-thinking-in-engineering-students-by-utilizing-integrated-online-modules

[12] R. S. Harichandran, N. O. Erdil, M.-I. Carnasciali, J. Nocito-Gobel, and C. Li, "Developing an entrepreneurial mindset in engineering students using integrated e-learning modules," *Adv. Eng. Educ.*, vol. 7, no. 1, 2018, Accessed: Feb. 02, 2023. [Online]. Available: https://eric.ed.gov/?id=EJ1199591

[13] H. J. Choi and J.-H. Park, "Difficulties that a novice online instructor faced: A case study," *Q. Rev. Distance Educ.*, vol. 7, no. 3, p. 317–322, 2006.

[14] T. Roman, K. Kelsey, and H. Lin, "Enhancing online education through instructor skill development in higher education," *Online J. Distance Learn. Adm.*, vol. 13, no. 4, p. 1–9, 2010.

[15] J. I. Vallade and R. Kaufmann, “Instructor misbehavior and student outcomes: Replication and extension in the online classroom,” *J. Res. Technol. Educ.*, vol. 53, no. 2, pp. 206–222, Apr. 2021, doi: 10.1080/15391523.2020.1766389.
[16] P. Kearney, T. G. Plax, E. R. Hays, and M. J. Ivey, “College teacher misbehaviors: What students don’t like about what teachers say and do,” *Commun. Q.*, vol. 39, no. 4, pp. 309–324, Sep. 1991, doi: 10.1080/01463379109369808.
[17] L. Pollettini Marcos et al., “Plug-and-play adaptive approach to integrating model-based systems engineering concepts into academic curriculum,” presented at the INCOSE IS 2022, Detroit, MI, Jun. 2022. doi: 10.1002/iis2.12969.
[18] V. Braun and V. Clarke, “Thematic analysis,” in APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological, Washington, DC, US: American Psychological Association, 2012, pp. 57–71. doi: 10.1037/13620-004.