Online Model-based Systems Engineering (MBSE) Bootcamp: A Report on Two Day Workforce Development Workshop

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***Abstract*— Academia or workforce development workshops can both increase the plausibility of a streamlined transition from a document-centric approach to MBSE frameworks, and aid the integration of Model-Based Systems Engineering (MBSE) within the current industry and the challenges faced, introducing MBSE concepts, tools, and languages. This paper reports on an online model-based system engineering Bootcamp conducted in collaboration with The University of Texas Rio Grande Valley and The University of Texas at El Paso. The importance of MBSE is emphasized throughout the online Bootcamp to a diverse group of audience i.e., students, faculty, and industry professionals unfamiliar with systems engineering. A set of predefined questions through pre and post Bootcamp surveys aided in determining the perceptions of MBSE and the effectiveness of the Bootcamp in increasing the knowledge of MBSE amongst participants. A positive knowledge gain was observed on the importance of systems modeling and MBSE across students, faculty, and industry personnel participants indicating the effectiveness of the online Bootcamp. A set of open-ended questions were targeted specifically for industry professionals from manufacturing, aerospace, healthcare, transportation, and software domains attending the Bootcamp for capturing the perceived challenges and obstacles according to them for implementing Model-Based Systems Engineering in their organizations.**

Keywords—MBSE, online bootcamp, workshop, model-based systems engineering, systems engineering

I. Introduction

Model-based system engineering (MBSE) is the structured use of modeling to support system requirements, design, analysis, verification, and validation that begins in the conceptual design phase and continues through the final life cycle phases [1]. Traditional document-centric approaches cannot integrate a coherent and consistent system's activities in all the system life cycle phases. According to Delligatti, the onerous effort of architecting and developing a system properly is not eliminated by MBSE; however, MBSE addresses the necessity for technical consistency throughout system definition and design stages. MBSE can offer a higher return on investment (ROI) because of its ability to develop cohesive and reliable system activities, whereas a document-centric approach cannot.

With the ongoing increase in the use and adoption of MBSE in industries, there is a need for the concept of what MBSE is to be introduced at both academic and industry levels. The research team explored current and past MBSE workshops and academic curriculum initiatives.

In a recent study by Bertz et al., the introduction of systems engineering to the workforce of German industrial companies in the fields of automotive engineering, mechanical and plant engineering, and electrical equipment provided a sharp increase in attendees' understanding. In addition, Bertz et al. mentioned that the introduction of systems engineering itself was a challenging and difficult task [2]. Do et al., discovered that while MBSE continues to grow across all types of industries, there is still an intrinsic hurdle in adopting MBSE concepts and techniques across the project lifecycle [3]. The attempt to integrate MBSE within a document-centric culture is challenging; nonetheless, the plausibility of such a transition can be aided if MBSE concepts and techniques are introduced sooner to the future workforce either through a workshop or via academic curricula. The vast majority of MBSE related workshops [2,3,4] observed are geared toward industry professionals rather than post-secondary students.

There is a need to introduce the concepts of MBSE early on to the upcoming workforce as well as embrace the initiative to introduce the importance of MBSE to industry professionals unfamiliar with Systems Engineering (SE). This paper reports on an online MBSE Bootcamp conducted with participant classification across undergraduate and graduate students, faculty, and industry professionals unfamiliar with MBSE. The contents of the Bootcamp were designed to provide a platform for audiences across the industry, and academia with insight on the Why, What, Who, and How aspects of MBSE.

In this document, Section II details the agenda and the participants of the online MBSE Bootcamp. Section III talks about the pre and post-survey analysis examining the data from the participants to see if they were able to successfully gain some new knowledge about what MBSE is and the role of MBSE in the development of complex systems. Section IV provides reflections on the Bootcamp and Section V includes the conclusions drawn in.

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II. Online MBSE Bootcamp

A. Workshop Description

The Online model-based systems engineering (MBSE) Bootcamp was a two-day workforce development workshop for bringing together experts in MBSE and Production Engineering to discuss the importance of MBSE in industries and academia. The main goal of the workshop was to provide a platform for audiences across the industry, and academia with insight on the 'Why, What, and How' aspects of MBSE. The Bootcamp activities addressed the national need for well-educated engineers and technicians. Workshop participants were provided with resources and training on model-based systems engineering that will further contribute to developing a competitive workforce of underrepresented citizens across all the careers stages in the Rio Grande Valley region and beyond impacting the manufacturing, automotive, and production industry.

The online model-based systems engineering (MBSE) Bootcamp was held by the University of Texas at Rio Grande Valley (UTRGV) and The University of Texas at El Paso (UTEP). This boot camp was intended for industry professionals, faculty at academic institutions, and students for introducing them to the importance of modeling and model-based systems engineering. The workshop was initially planned to be held in person at UTRGV; however, due to the COVID-19 pandemic and to operate based on center for disease control guidelines, the workshop was transitioned to a synchronous-online format.

The research team explored several online open-source and paid platforms to conduct the Bootcamp. Zoom, an online synchronous meeting tool, was identified for its features such as annotation tools, participant polls, creation of break-out rooms, and video/screen sharing capabilities. Selecting Zoom for the online Bootcamp was affirmed with several case studies observed in literature attesting to its applicability and effectiveness for dynamic learning and technology training across various domains [5,6,7,8]. An online invitation and a link for registration were sent out via professional organizations, academic institutions in the United States and across the world, and manufacturing organizations in the Rio Grande Valley region and across the U.S. The agenda of this synchronous-online Bootcamp as illustrated in Table I, was spread over two days which included one keynote speaker and two hands-on active workshops.

TABLE I. Online MBSE Bootcamp agenda

	Time	Program	Topic
Day 1	10:00 AM	Workshop Introduction	
	10:30 AM	Keynote Speaker	Using MBSE to Perform Functional Analysis to Analyze Customer Requirements
	1:00 PM – 4:30 PM	Workshop - 1	Supporting development of a complex system through modeling, simulation and MBSE
Day 2	9:00 AM to 4:00 PM	Workshop - 2	Using Models and Simulation in Support of Digital Twins and Industry 4.0

B. Bootcamp Day 1 – Addressing the need and importance of MBSE

Day one began with the introduction to the Bootcamp followed by the keynote speech. The keynote served as a platform for discussion on the use of MBSE to perform functional analysis to analyze customer requirements. It is well known that according to the core principle of systems engineering (SE), SE projects start hierarchically down with customer need, requirements definition which is then decomposed into the requirements for subsystems and then a level down. The keynote speaker discussed the role of system architectures, tools, and methods for architecture development with pre-defined requirements. A key discussion was on if this is the only time when the tools and methods for architecture development are useful. The impact of deviations from SE theory was discussed with a brief overview of systems engineering and then walk through an example of a top-level requirement handed down from a customer to its program implementation.

The interactive keynote session was followed by a workshop on supporting the development of the complex system through modeling, simulation, and Model-Based System Engineering. There has been an increasing trend in the size and complexity of systems making them more difficult to understand, validate, specify their behavior and functionality, create its architecture and design, develop, and verify their defined functionality and behavior. System development based on paper documentation and manual verification and validation is not enough to handle the complexity and tight development schedules. The use of models and simulations throughout the system lifecycle to support systems analysis, verification, and validation has become imperative to build complex systems with quality. Models and simulations provide the means to understand, define, and unambiguously communicate both system requirements and system solutions (architecture). Models can be used to provide a visual representation of the problem and/or system solution in artifacts produced in mission analysis, stakeholder requirements, system requirements, architecture, and design. Models have syntax and semantics that facilitate consistent use of the model, its semi-formal definition, and its interpretation avoiding the ambiguity embedded in natural language.

Through the workshop participants were introduced to different types of models and simulations addressing different purposes and needs, types, fidelity, and the complexity of their abstractions and analyses involved. The workshop stressed characteristics of models and simulations; use of models and simulations to understand different system's aspects; use of models to verify systems requirements, validate system artifacts with the customer, and determine the affordability to meet performance requirements. In addition, all the participants of the workshop were introduced to the use of models and simulations to support the entire system life cycle through Model-Based Systems Engineering (MBSE).

C. Bootcamp Day 2 – Importance of Modeling in Manufacturing and Production Engineering

The goal of the activities on day two of the Bootcamp was to carry over the concepts addressing the importance of model-based thinking applied to real-time manufacturing case studies. The workshop started with an introduction to the importance of modeling and simulation using the SIMIO tool for modeling, visualizing, and analyzing manufacturing systems for improving business operations. The workshop concluded with exploring the benefits of recent disruptive technologies that are providing unique support for digital transformations.

D. Participant Background and Demographics

Several participants from industry and academia have registered and attended the Bootcamp. A total of 159 participants attended the Bootcamp both days with geographical distribution of 93 participants from the United States, 61 from Mexico, 2 from Spain, 1 from Portugal, 1 from India, and 1 from Brazil.

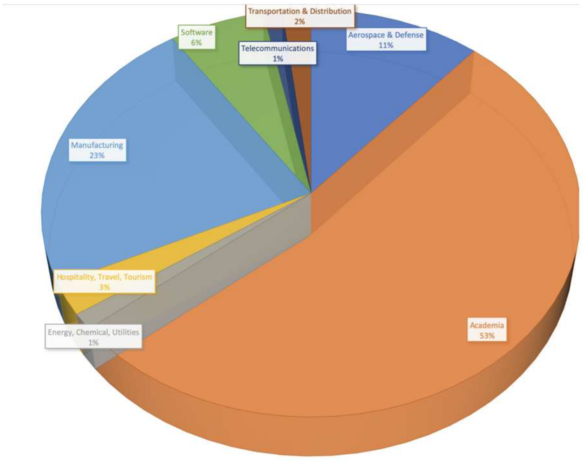

Fig. 1. Bootcamp participant classification

The distribution of the participant affiliation as illustrated in Figure 1 included 53% from academia (comprising both faculty and students), and the rest from industries with 23% from manufacturing, 11% from aerospace and defense, 6% from software, 3% from hospitality, travel, and tourism, 2% from transportation and distribution, and 1% each from telecommunications, and energy and utilities. It is to be noted that the audience of the Bootcamp were not familiar with what model-based systems engineering is before their registration and participation.

III. Data Analysis

The impact of COVID-19 was the main driver for the change in the format of the Bootcamp from in-person to online. To determine the effectiveness of this transition, the online Bootcamp conducted was treated as a medium to analyze and measure if the participants were able to successfully gain some new knowledge about what MBSE is and the role of MBSE in the development of complex systems using the instruments of pre and post Bootcamp surveys. The key questions of the pre and post-surveys were identified to glean the participant understanding of MBSE and are illustrated in Table II. To understand the knowledge gained of each participant for a comparative analysis of the pre-and-post surveys all the participants were asked to generate an anonymous ID for their participation, a combination of their name, birthday, and favorite color and were requested to use the same combination while completing both surveys. This helped in undertaking a more comprehensive analysis of the data gathered.

TABLE II. Pre and Post-Survey Questions and their Relevance

Relevance	Bootcamp Pre-Post Survey Questions
Participant Demographics	Please identify your classification; Identify Gender Demographic
Understanding the basics of System Modeling	What do you need to consider to select a type of model (Q1); What is the syntax of a model and its intended purpose (Q2); What are the semantics of a model (Q3)
Use and importance of MBSE	Model-Based systems engineering (MBSE) can be used in support of (Q4); Traditional systems engineering focuses on creating and managing documentation about a system whereas Model-Based Systems Engineering focuses on developing, managing, and controlling a model of the system (Q5); Two important characteristics of model-based systems engineering are (Q6); Which of the following could result in inconsistent and incorrect documentation (Q7)
Implementation of MBSE	When applied to systems, MBSE promotes development over document-driven development (Q8); What are some reasons an organization would consider implementing model-based systems engineering (Q9)
Adoption of MBSE	What kind of projects in your organizations do you see having a scope for transition to an MBSE approach (Post-Survey); Going Forward, the most challenging obstacles to implementing MBSE in our organization are (Post-Survey)

A. Participant Demographics

As illustrated in Table II, for the two questions identified for this category the aim was to understand the distribution of the participants and their demographics. 32.61% of the participants were students, 28.26% were faculty from academic institutions, and 36.96% were industry professionals, with 2.17% participants preferring not to answer the questions. From the aforementioned, 78.72% of the participants were male and 21.28% Female.

B. Familiarity with MBSE

The research team had to establish first if the participants had any exposure to MBSE before attending the Bootcamp. An open-ended question was asked to attendees to explain in their terms what MBSE is to them so that the research team can understand the familiarity with MBSE of the participants attending the Bootcamp. In the pre-survey, 51% of the participants responded that they were not sure of what MBSE is. Additionally, the rest of the participants expressed MBSE to be either an approach to building 3D computer models for simulations or a way to design and analyze product development. Interestingly, two out of all the participant responses indeed identified MBSE to be a methodology where the system is modeled such that information can be exchanged with others rather than the traditional document-based approach, indicating the familiarity with MBSE of these two participants.

The analysis of participant responses in the post Bootcamp survey indicated that 18% of the participants were still unfamiliar with MBSE based on their responses which were either ‘not sure’ or ‘do not know’. The rest 82% of the participants expressed MBSE as a way of using models to be more explicit than documentation, using models to represent systems and system of systems in a model-centric approach, using modeling tools to help understand complex systems better, a method that communicated necessary system information by and eliminate the unnecessary, and as a method that relies on domain models rather than document-based to maximize information exchange. This at a holistic level indicates that all the participants were successfully introduced to and became familiar with the idea of MBSE.

C. Understanding the basics of Systems Modeling

Three multiple-choice questions were used to measure the participant's understanding of the concepts in systems modeling. For the question '*What do you need to consider to select a type of model*' participants were given five options to choose from to understand the aspects of using semantics and goals of modeling a system. When asked to identify 2 options to consider when selecting a type of model, about 53.49% of the participants selected at least one out of the two accurate options, i.e., *The intended semantics that you wish to capture and convey to a viewer* and *The goals that the modeler wishes to accomplish in the application of a model*. Likewise, 73.53% of participants chose at least one out of the two accurate options during the post-survey. Table III provides a summary of the analysis for the pre and post-survey results.

TABLE III. Q1 TYPE OF MODEL - ANALYSIS REPRESENTING THE PRE AND POST-SURVEY RESULTS

Participant	Pre-Survey At Least 1 correct	Post-Survey At Least 1 correct	Pre-Survey 2 correct	Post Survey 2 correct
Student	73.33%	55.56%	0.00%	11.11%
Faculty	36.36%	77.78%	0.00%	44.44%
Industry	43.75%	90.91%	6.25%	54.55%
Unidentified	100%	60.00%	0.00%	0.00%
Total	53.49%	73.53%	2.33%	32.35%

There is a positive increase of 20.04% of participants choosing one out of the two appropriate options. Nonetheless, only 2.33% of the participants selected both the appropriate options. During the post-survey, about 32.35% of the participants selected the two correct options. This means a positive difference of 30.03% of participants selecting the two correct options.

The research team measured participants' understanding of the importance of syntax and its role in creating models. Participants identified an appropriate response indicating its intended purpose. During the pre-survey, about 25.58% of the participants selected the appropriate response, *A set of constructs, and the associated rules used to create models*. Likewise, in the post-survey, about 47.06% of the participants selected the appropriate answer. This represents a positive difference of 21.48% of participants choosing the correct response. Table IV provides a summary of the analysis for the pre and post-survey results.

Similarly, to determine the ability of the participants to differentiate between syntax and semantics of a model the participants were asked to identify *what the need for semantics is for conveying the meaning of a model*. About 18.60% of the participants responded by identifying the appropriate option, *The intended meaning being conveyed by the use of a model*, during the pre-survey vs 41.18% in the post-survey. This represents a positive difference of 22.57% of participants selecting the correct answer. Summarized in Table V is the analysis representing the pre and post-survey results.

TABLE IV. Q2 IMPORTANCE OF A SYNTAX - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey Correct	Post-Survey Correct	Difference
Student	40.00%	33.33%	-6.67%
Faculty	9.09%	66.67%	57.58%
Industry	25.00%	45.45%	20.45%
Unidentified	0.00%	40.00%	40.00%
Total	25.58%	47.06%	21.48%

TABLE V. Q3 SYNTAX AND SEMANTICS - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey Correct	Post-Survey Correct	Difference
Student	26.67%	22.22%	-4.44%
Faculty	0.00%	66.67%	66.67%
Industry	25.00%	18.18%	-6.82%
Unidentified	0.00%	80.00%	80.00%
Total	18.60%	41.18%	22.75%

As a summary, the participant responses on their understanding of the basics of Systems Modeling showed a knowledge gain, across all the participant categories, when compared to before and after they participated in the Bootcamp.

D. Use and Importance of MBSE

Three multiple-choice questions and one polar question were defined to measure the participant's understanding of the use and importance of MBSE.

The research team measured the understanding of participants on activities that MBSE supports. Participants selected responses associated with validation activities throughout the lifecycle, managing system complexity, reducing test case scenarios, and automated planning and monitoring. In the pre-survey about 60.47% of the participants selected at least one out of two appropriate options, i.e., *validation activities throughout the lifecycle* and *managing system complexity*. Likewise, 79.41% of the participants in the post-survey selected one out of two options. These represent a positive difference of 18.95% of the participants selecting at least one out of two appropriate options. Nonetheless, only 9.30% of the participants selected the two correct options. In comparison, during the post-survey, about 17.65% of the participants selected the two appropriate options representing a positive difference of 8.34%. Table VI provides a summary of the analysis for the pre and post-survey results.

The research team identified the participants' ability to differentiate traditional systems engineering from the MBSE approach. Participants were asked to identify true or false for the statement '*Traditional systems engineering focuses on creating and managing documentation about a system*' whereas '*Model-Based Systems Engineering (MBSE) focuses on developing, managing, and controlling a model of the system*'. In the pre-survey, about 74.42% of the participants selected the appropriate option (i.e. False) while about 76.47%

of the participants chose false in the post-survey. This represents a positive difference of 2.05% of participants choosing false. Table VII provides a summary of the analysis for the pre-and post-survey results.

TABLE VI. Q4 UNDERSTANDING MBSE ACTIVITIES - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey At Least 1 correct	Post-Survey At Least 1 correct	Pre-Survey 2 correct	Post Survey 2 correct
Student	66.67%	44.44%	6.67%	11.11%
Faculty	54.55%	55.59%	9.09%	22.22%
Industry	62.50%	90.91%	12.50%	18.18%
Unidentified	0.00%	100.00%	0.00%	20.00%
Total	60.47%	79.41%	9.30%	17.65%

TABLE VII. Q5 TRADITIONAL SE VS. MBSE - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey Correct	Post-Survey Correct	Difference
Student	80.00%	55.56%	-24.44%
Faculty	63.64%	66.67%	3.03%
Industry	75.00%	90.91%	15.91%
Unidentified	100.00%	100.00%	0.00%
Total	74.42%	76.47%	2.05%

The research team measured the participants' ability to recognize the characteristics of MBSE. About 53.49% of the participants selected at least one out of the two appropriate options during the pre-survey. Likewise, about 76.47% of the participants selected at least one out of the two appropriate options. These options were '*Views are generated from a model' and 'The approach is model-centric diagram-centric'*. This reflects a positive difference of 22.98% of participants selecting at least one out of the two options. On the other hand, about 25.58% of the participants chose the two appropriate options in the pre-survey vs 38.24% of the participants selecting the two in the post-survey representing a positive difference of 12.65%. Table VIII provides a summary of the analysis for the pre-and post-survey results.

TABLE VIII. Q6 MBSE CHARACTERISTICS - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey At Least 1 correct	Post-Survey At Least 1 correct	Pre-Survey 2 correct	Post Survey 2 correct
Student	66.67%	55.56%	33.33%	22.22%
Faculty	36.36%	88.89%	9.09%	44.44%
Industry	56.25%	81.82%	31.25%	45.45%
Unidentified	0.00%	80.00%	0.00%	40.00%
Total	53.49%	76.47%	25.58%	38.24%

Similarly, when asked about identifying practices that could result in inconsistent and incorrect documentation, about 46.51% of the participants responded appropriately (*Having different practitioner groups working on silos*) in the pre-survey while 50% of participants responded correctly in the post-survey. This means a slightly positive difference of 3.49% of the participants selecting the correct answer. Table IX provides a summary of the analysis for the pre-and post-survey results.

TABLE IX. Q7 PRACTICES LEADING TO INCORRECT DOCUMENTATION - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey Correct	Post-Survey Correct	Difference
Student	46.67%	33.33%	-13.33%
Faculty	36.36%	55.56%	19.19%
Industry	56.25%	63.65%	7.39%
Unidentified	0.00%	40.00%	40.00%
Total	46.51%	50.00%	3.49%

Collectively, across all the participant categories a knowledge gain was observed comparatively among pre-and post-surveys across the questions framed to measure participant understanding of the use and importance of model-based systems engineering.

E. Implementation of MBSE

Two multiple-choice questions were asked to measure the participants' knowledge gained in the Bootcamp from a perspective of implementing MBSE.

Applied to systems, when asked what kind of development MBSE promotes over document-driven development, 48.84% of the participants responded correctly '*Model-driven*' in the pre-survey vs 79.41% in the post-survey among the options to choose from *model-driven, document-driven, memorandum driven, configuration driven, and milestone-driven*. This represents a positive difference of 30.57%. An interesting observation is that faculty participants have shown the most drastic increase by going from a 36.36% to 100%, thus resulting in a positive difference of 63.64% of faculty participants.

Participants were asked to choose two appropriate responses that translate to their understanding of why organizations usually consider implementing model-based systems engineering. About 67.44% of the participants selected either '*To improve the communication among the development stakeholders*' or '*To enhance the capture of knowledge and effectively reuse it*' during the pre-survey. In comparison, about 79.41% of the participants selected either of the aforementioned. On the other hand, about 13.95% of the participants selected both the appropriate options in the pre-survey while 20.59% in the post-survey, representing a positive difference of 6.63%. Table X provides a summary of the analysis for the pre-and post-survey results.

TABLE X. Q8 NEED TO IMPLEMENT MBSE - ANALYSIS REPRESENTING THE PRE-AND POST-SURVEY RESULTS

Participant	Pre-Survey At Least 1 correct	Post-Survey At Least 1 correct	Pre-Survey 2 correct	Post Survey 2 correct
Student	93.33%	55.56%	13.33%	11.11%
Faculty	45.45%	100.00%	9.09%	44.44%
Industry	62.50%	90.91%	18.75%	9.09%
Unidentified	0.00%	60.00%	0.00%	20.00%
Total	67.44%	79.41%	13.95%	20.59%

F. Adoption of MBSE

Two open-ended questions were included in the post-survey for the participants to reflect on their learning and understanding of MBSE in the online Bootcamp. One question for industry personnel asked them to identify opportunities on what type of projects may transition to an MBSE approach. Among industry participants who are self-classified belonging to manufacturing industries, there is an incline towards the interest in applying MBSE to *reduce duplicity of system functions*, *developing resiliency models for supply chain*, and *system design*.

Further, when asked the industry participants, going forward, the most challenging obstacles according to them for implementing Model-Based Systems Engineering in their organization are, a common theme surrounding *organizational support*, *infrastructure*, and *acceptance among people was observed*. When further analyzed, the key reasons gleaned from the text data included *lack of training on MBSE*; *lack of compromise on the stakeholder's end for MBSE deliverables*; *teamwork*; *and support from management for implementing MBSE*. In addition to identified challenges, a common theme surrounding learning, cultural acceptance, and the ability of the project managers to justify the cost of MBSE implementation were mostly reflected upon.

IV. Reflection on the online MBSE Bootcamp conducted

The online synchronous format was treated as a medium to analyze and measure if the participants were able to successfully gain some new knowledge about *what MBSE is* and *the role of MBSE in the development of a complex system*.

The key questions identified for the pre, and post participant surveys acted as instruments in measuring the participant knowledge gain. A positive knowledge gain was observed in the faculty and industry professional participant categories across all the aspects covered in the Bootcamp i.e., in understanding the basics of systems modeling, use and importance of MBSE, and understanding the implementation of MBSE.

The format of the Bootcamp spread over two days needed the participants to engage and pay attention consistently. It is observed that the participants were active mostly during the morning sessions with their participation slowly tapering down the rest of the day. It was difficult to keep a track of all the 159 participants virtually and to pick up on their nonverbal cues of fatigue. Termed as zoom fatigue [7] the constant attention required repeatedly by the participants in web conference meetings, could have influenced the ability of the Bootcamp participants to retain a context for the verbal communication being shared. This raises a need to explore the implications a format change could have if the Bootcamp were to be done in person – retaining the same schedule and program structure. Further, analysis of the responses by student participants to the pre and post-survey questions 1, 3, and 7 resulted in a negative difference, indicating that students chose the appropriate answers to pre-survey questions and not for the post-survey. The reason for this is yet to be analyzed by the authors. Nonetheless, this brings forward the aspects of, Is SE knowledge a prerequisite for learning MBSE? Or can one start directly with MBSE? Likewise, how much training is needed in SE before introducing MBSE? All these aspects should be addressed when developing future MBSE workshops across all the participant categories new to MBSE.

V. Conclusion

The online Model-based Systems Engineering Bootcamp emphasized introducing the concepts of MBSE to a wide spectrum of audiences i.e. students, faculty, and industry professionals. The Bootcamp was tailored to the audience who were not familiar with what Model-Based Systems Engineering is before their registration and participation in the Bootcamp. Utilizing a set of predefined questioners for the Bootcamp participants, pre and post-Bootcamp surveys were used as an instrument to measure the effectiveness of the online Bootcamp structure. A positive knowledge gain was observed in the participants across all the aspects covered in the Bootcamp i.e., in understanding the basics of systems modeling, use and importance of MBSE, and understanding the implementation of MBSE. The analysis of the responses by student participants to the pre and post-survey questions 1, 3, and 7 indicated a negative difference and the reason for this is yet to be explored by the authors. Possible correlations could exist to this effect with the student level classification and their knowledge background in terms of their familiarity with SE. The next steps in terms of measuring the effectiveness of the synchronous online medium of the Bootcamp include comparing the results with an in-person session – retaining the same schedule and program structure.

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