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Cultivating Goal Orientation in Space Architect Education

A Systems Engineering Workshop with Rubric-Based Self-Assessment

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AUTHORS

Kohei Tanaka, Tsubasa Ito, Ryoya Inomata, and Seiko Shirasaka

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I N C O S E   P U B L I C A T I O N S

Cultivating Goal Orientation in Space Architect Education: A Systems Engineering Workshop with Rubric-Based Self-Assessment

Kohei TANAKA
Keio University
4-1-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8526 Japan
koh-tanaka@keio.jp

Tsubasa ITO
Keio University
4-1-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8526 Japan
ito-tsubasa@keio.jp

Ryoya INOMATA
Keio University
4-1-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8526 Japan
r.inomata@keio.jp

Seiko SHIRASAKA
Keio University
4-1-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8526 Japan
shirasaka@keio.jp

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Abstract

The increasing complexity of space development projects has created a growing need for professionals capable of integrating multidisciplinary knowledge and leading design processes with a clear mission purpose. To address this need, this study designed and implemented a practical educational program based on Model-Based Systems Engineering (MBSE) to cultivate "space architects." Unlike conventional skill-oriented MBSE training, this program began by identifying recurring issues observed in student-led space projects and defining the target human-resource profile required to address them. Building on this competency model, the program integrates three core modules—Systems Engineering (SE), Project Management (PM), and Systems × Design Thinking (S×D)—and employs a rubric-based framework to promote self-assessment, reflection, and continuous improvement. A two-cycle workshop was conducted to examine how rubric-based self-assessment and instructional design influence the development of goal orientation, a key competency for MBSE practitioners. In the first cycle, participants connected mission objectives with design elements following guided instruction; in the second, an additional mission requirement ("wildfire observation") was introduced to intentionally disrupt goal orientation. Rubric scores increased after the first cycle and declined after the second, consistent with the educational intent of allowing learners to experience both the strengthening and disruption of goal orientation. These results suggest that deliberately incorporating goal disruption—combined with structured reflection—enhances learners' metacognitive awareness of design purpose. Moreover, the study demonstrates the value of grounding MBSE education in real project challenges and competency-based design to cultivate professionals who approach system design from a purpose-driven perspective.

Keywords

Model-Based Systems Engineering, Systems Engineering Education, Space Architect, Goal Orientation, Rubric-Based Assessment.

1. Introduction

In recent years, space development missions have become increasingly diverse and complex, driven by factors such as the multifunctionalization of communication satellites, the expansion of large-scale exploration projects, and the entry of private companies seeking to reduce development costs and schedules (Hill et al., 2024, March). Against this backdrop, there is a growing demand for specialists capable of comprehensively designing and managing multiple subsystems, balancing the interests and constraints of diverse stakeholders, and formulating consistent mission concepts. These specialists are generally referred to as "systems architects," and in the space sector, more specifically as "space architects" (Hill et al., 2024, July).

In response to these trends, the National Aeronautics and Space Administration (NASA) is actively promoting the adoption of Model-Based Systems Engineering (MBSE) to accelerate the transition to a model-driven design process across all projects (Hill et al., 2024, March). The European Space Agency (ESA) has likewise emphasized the urgent need to develop personnel capable of structurally designing entire space missions and has institutionalized MBSE training programs for professionals (Lorenzo Alvarez et al., 2018). In higher education, institutions such as the University of Arizona and the Industrial Engineering School (ETSII) have reported initiatives that integrate MBSE into undergraduate curricula (University of Arizona, n.d.; Salado et al., 2019; Fernández & Moreno, 2016).

This trend extends beyond the space sector and is attracting increasing attention from both industry and academia. For example, in the automotive industry, MBSE-based educational programs have been introduced to address the design of complex, highly integrated systems such as Advanced Driver Assistance Systems (ADAS) and Electric Vehicles (EVs). Similarly, under Germany's "Industrie 4.0" strategy, training programs for architects that leverage digital-thread technologies are being advanced (Akundi et al., 2024).

Nevertheless, existing educational curricula continue to face significant challenges. Many programs place disproportionate emphasis on tool-operation skills while insufficiently fostering upstream design competencies such as conceptualization and integrated decision-making (Bajczi et al., 2024; Dalal et al., 2021). Furthermore, formalistic modeling education that overlooks user perspectives and goal-oriented design has been criticized for impeding meaningful design decisions (Greene et al., 2017). MBSE should not be treated merely as a diagramming tool; rather, it must be recognized as a decision-support methodology for verifying trade-offs and validating design soundness. Therefore, education should prioritize "the thinking behind the model" before "the operation of the tool" (Reichwein & Paredis, 2011).

In light of these challenges, the "Space Architect Development Program" proposed in this study is based on the following three educational principles:

(1) to provide the theoretical foundations and practical applications of Systems Engineering (SE) and MBSE, thereby cultivating system-oriented thinking in design and operations rather than mere tool-handling skills;

(2) to support goal-oriented design from the conceptual stage by integrating systems thinking and design thinking into educational materials, fostering the ability to formulate creative yet logically sound solutions to complex societal challenges; and

(3) to develop the integrated perspective and implementation capabilities required of future systems architects through practical exercises in a Project-Based Learning (PBL) format, enabling learners to apply the acquired thinking methods to real-world problems.

2. Related Work

2.1. Trends in MBSE Education

Model-Based Systems Engineering (MBSE) is an approach that represents system structures, functions, and behaviors within a consistent model to improve change-impact analysis, traceability, and reviewability (Reichwein & Paredis, 2011). Recent educational initiatives in the U.S. and Europe emphasize fostering integrated design and decision-making skills.

At the University of Arizona, a graduate-level MBSE course employs SysML v1.6 and a simplified OOSEM process using Magic System of Systems Architect, guiding students through a 15-week modeling project (University of Arizona, n.d.). Salado et al. (2019) found that while conceptual understanding was easy, applying it effectively was difficult; complexity often shifted focus away from design purpose. They advocate a studio-based approach with iterative critique. Fernández and Moreno (2016) applied the ISE & PPOOA process in SysML to teach requirements, functional, and physical design using a disaster-rescue-robot case study, concluding that simple tools and process understanding are more effective for beginners than mastering complex MBSE tools. Yang et al. (2023) demonstrated that simulation-based MBSE improves causal reasoning and systems thinking.In Japan, Yamasaki et al. (2023) applied MBSE to space engineering education using the HEPTA-Sat kit, effectively linking hardware design with model-based representations.

However, many programs still overemphasize tool usage while insufficiently focusing on MBSE philosophy and decision-making skills (Bajczi et al., 2024; Dalal et al., 2021). Evaluation often relies on quantitative metrics, making it difficult to assess growth in architect-level thinking. In addition, Busch et al. (2024) emphasize the importance of integrating simulation-based verification into MBSE practice to bridge the gap between conceptual modeling and design validation — a connection still underrepresented in current educational implementations.

2.2. Architect Development Programs in Practice

Worldwide, MBSE-based system-architect training programs are expanding. NASA's Digital Engineering Transformation (DET) includes the Model-Based Capability Assessment (MBCM), toolchain interoperability improvements, and cloud-based PLM trials (Hill et al., 2024, March; Hill et al., 2024, July). Its APPEL program defines role-specific skills and uses on-demand learning and mentoring, though cultural change remains a challenge.

The European Space Agency (ESA) has developed an ECSS-aligned neutral MBSE methodology implemented in SysML via Cameo and Enterprise Architect and applied to missions such as Argonaut, MSR-ERO, and LISA (Lorenzo Alvarez et al., 2018). While the structure supports lifecycle consistency, partner process differences and cultural gaps still hinder interoperability. Moreover, the ESA MBSE Working Group (2022) collaborates with the Swiss Federal Institute of Technology Lausanne (EPFL) to provide concurrent-engineering and MBSE training programs, highlighting a growing emphasis on experiential and collaborative learning within European MBSE education.

These examples show that MBSE functions both as a means of developing organizational capabilities and as a way to foster the architect's systems perspective, while also revealing persistent challenges in workforce development and cultural adoption.

2.3. Position and Contribution of This Study

A recurring challenge in MBSE education is the overemphasis on modeling-tool operation and insufficient attention to holistic systems thinking and design decision-making. Busch et al. (2024) highlight that effective MBSE education must integrate models, ensure traceability, and incorporate simulation-based verification while fostering interdisciplinary communication skills.

Unlike earlier programs that separated MBSE skill training, design-process education, and project-based learning (PBL), this study integrates these elements to cultivate architectural thinking through MBSE. The program focuses on how learners connect design activities with underlying purpose—strengthening goal orientation as a key competency for future space architects.

In this study, the focus was placed on a Systems Engineering (SE) workshop that used a collaborative digital whiteboard tool to help participants internalize MBSE-oriented thinking without relying on MBSE software tools in this specific exercise. While MBSE provides the conceptual foundation of the overall program, this workshop specifically emphasized purposeful, hands-on SE design discussions aimed at fostering awareness of goal orientation as the basis for model-based reasoning.

3. Educational Design of the Space Architect Development Program

3.1 Overview of the Program

The "Space Architect Development Program Utilizing MBSE" was implemented under Japan's FY2024 Aerospace Science and Technology Promotion Fund (Ministry of Education, Culture, Sports, Science and Technology, MEXT). The program is led by the Graduate School of System Design and Management (SDM), Keio University, in collaboration with Wakayama University, Osaka Metropolitan University, and the University of Fukui.

The objective of the program is to develop next-generation "space architects" by combining theoretical instruction with practical and interdisciplinary experience centered on Model-Based Systems Engineering (MBSE). Over its five-year duration, the program provides a structured curriculum and continuous mentoring to foster individuals with system-oriented thinking and implementation capability in student-led space projects across participating institutions.

3.2 Educational Framework

" Issues" in this program summarize the difficulties actually observed in past student projects and those recognized by faculty in educational settings. Based on these issues, the program defines the professional persona "Space Architect" as the target profile capable of addressing such challenges. To ensure that this persona aligns with real-world architect roles, competencies were derived by referencing the INCOSE Systems Engineering Competency Framework (INCOSE, 2022) and the International Engineering Alliance Graduate Attributes and Professional Competencies (IEA, 2021).

Using these analyses, the program design was constructed to bridge the gap between current learners and the desired competencies. The curriculum consists of three interrelated modules: 1. Systems × Design Thinking (S×D) , 2. Systems Engineering (SE) , 3. Project Management (PM).

These modules provide a practical and interdisciplinary foundation that supports system-level reasoning and decision-making. A rubric-based evaluation system is implemented to assess learning outcomes qualitatively and quantitatively. The rubric promotes formative feedback and self-reflection while ensuring consistency between educational goals and instructional practice. Because the program targets long-term, project-based learning, it emphasizes enabling learners to visualize their growth and regulate their development through rubric-guided reflection.

A distinctive feature of the framework is its use of MBSE not merely as a modeling methodology but as an educational concept. Learners are expected to understand relationships and dependencies among subsystems through modeling, extract and visualize essential information from complex situations, and develop the ability to compare design alternatives and make informed decisions.

The overall structure of this educational design framework is illustrated in Figure 1, which depicts the relationships among Issues, Persona, Competency, Program, and Rubric.

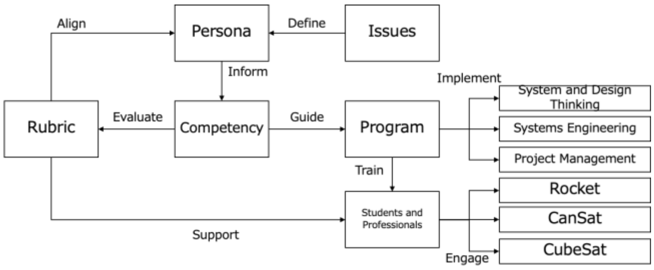

Figure 1. Educational Design Framework of the Space Architect Development Program.

Within this program, various educational activities are implemented across multiple levels. Among them, the present study reports on an introductory Systems Engineering (SE) workshop designed to cultivate goal orientation—a competency regarded as foundational to applying MBSE effectively in later phases of the program.

3.3 Objectives of the Program

The program aims to foster professionals who can autonomously define project visions and goals using MBSE, oversee complete systems, integrate multidisciplinary knowledge, and design and implement complex space systems. It builds upon more than fifteen years of architect-education experience at Keio SDM and the practical engineering experience of partner institutions through CubeSat, CanSat, and hybrid-rocket projects.

3.4 Target Human Resource Profile

Through discussions among partner institutions, the following recurring issues were identified in student-led space-development projects: superficial mission-goal setting, unclear system structuring, weak project management, and limited awareness of space-specific constraints. These problems stem not from technical skill shortages but from insufficient ability to structurally frame purposes and to integrate diverse expertise toward realizing shared value. Accordingly, the program seeks to nurture “space architects” who can set project visions and goals, design complex systems by integrating perspectives across disciplines, and lead projects toward realization.

Three core competencies are defined:

1. Value Co-Design Competency – Integrating systems and design thinking to define purposes and values collaboratively with diverse stakeholders and to design missions through dialogue.

2. Model Integration Competency – Applying MBSE/SE principles to structurally organize relationships, constraints, and requirements while making justified and traceable decisions through models.

3. Agile Leadership Competency – Leading teams under changing conditions through agile management and continuous learning to realize value creation.

These competencies span four skill areas: mission formulation, complex-system integration, project execution, and basic space-engineering knowledge. MBSE serves as the methodological foundation connecting these skills, emphasizing the cultivation of a mindset that understands complexity structurally and creates value through relationships with others rather than focusing on tool operation.

3.5 Training Methodology

The curriculum is built upon three pillars:

1. Systems × Design Thinking (S×D): An approach developed at Keio SDM that integrates systems thinking and design thinking to promote purposeful and collaborative discussion.

2. MBSE/Systems Engineering (SE): Providing the basis for visualizing requirements, structures, and behaviors and for verifying consistency and managing traceability.

3. Project Management (PM): Teaching frameworks for WBS, risk management, scheduling, and task allocation required for project execution.

Students first learn these fundamentals through short-term workshops and then apply the knowledge in long-term projects such as CubeSat, CanSat, and hybrid-rocket development. These activities are operated in parallel (parallel-accompaniment model), allowing students to immediately apply insights from short-term exercises to actual projects and to restructure project issues in subsequent workshops, thereby forming an iterative learning loop.

3.6 Evaluation Method

A rubric defining target competencies through observable behavioral indicators supports learners’ self-assessment and reflection. Before each workshop, the rubric is shared so participants can set learning goals; afterward, teams review outcomes, identify gaps, and discuss improvements. This iterative use enables learners to reflect on their learning process and adjust how they apply and think about methods toward subsequent challenges. The rubric functions as a formative assessment—a mechanism to support learning rather than to grade results. Tool-operation skills and factual knowledge are deliberately excluded from evaluation; conceptual understanding, structural thinking, and collaborative design abilities are emphasized.

4. Results

4.1 Workshop Context, Objectives, and Implementation

As part of the Space Architect Development Program, an introductory Systems Engineering (SE) workshop was conducted to examine how goal-oriented design thinking can be cultivated before introducing formal MBSE tool use. While MBSE serves as the conceptual foundation of the overall program, this workshop focused on developing the mindset required to apply MBSE effectively—particularly the ability to connect design rationale with higher-level mission objectives.

The exercise was implemented using a collaborative digital whiteboard tool, which allowed participants to visualize and discuss relationships among requirements, functions, and system behaviors without relying on specific modeling software. This environment was intentionally designed to serve as a bridge between traditional SE education and MBSE thinking, emphasizing reasoning about system architecture rather than producing formal SysML diagrams (cf. Reichwein & Paredis, 2011).

As shown in Figure 2, the workshop followed two consecutive design cycles based on fundamental SE processes. Participants were guided through requirements definition and architecture design phases to simulate real-world engineering decision-making. A rubric was administered at three stages—before the first cycle, after the first cycle, and after the second cycle—to prompt self-reflection and capture changes in goal awareness.

The participants consisted of 18 undergraduate students from Osaka Metropolitan University, organized into four teams, focusing on the conceptual design of an artificial satellite. In the first cycle, the mission was to capture orbital debris. In the second cycle, an additional requirement—"the satellite shall also observe forest fires"—was introduced to deliberately challenge participants' goal orientation. This modification required them to reconsider the System of Interest (SoI), re-evaluate stakeholder requirements, and adapt their designs accordingly.

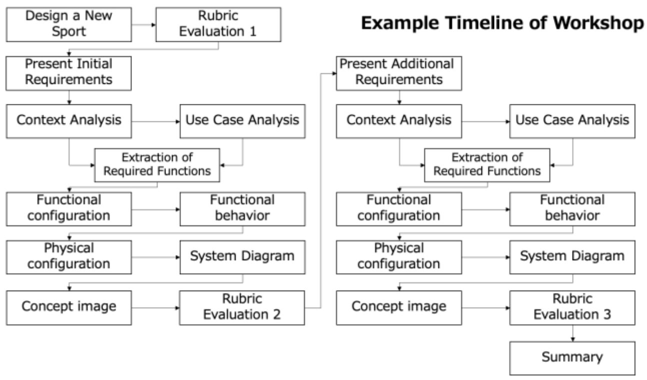

Figure 2. Timeline of the two-cycle workshop.

4.2 Deliverables and Rubric Results

In the second cycle, a new wildfire-observation mission was added to the debris-capture satellite developed in the first cycle. This modification was intended to encourage a reconstruction of the System of Interest (SoI) and a fundamental review of stakeholder requirements, leading to revisions in use cases and system design to align with the updated mission objectives.

As shown in Figures 3 and 4, some teams incorporated wildfire-observation elements—such as infrared sensors and the transmission of wildfire data to the ground station—into their context and system diagrams, and added "Wildfire Observation" to their use cases (Table 1). However, in all teams, these changes were limited to partial modifications within the existing structure, without a full SoI reconstruction or a fundamental re-evaluation of stakeholder requirements.

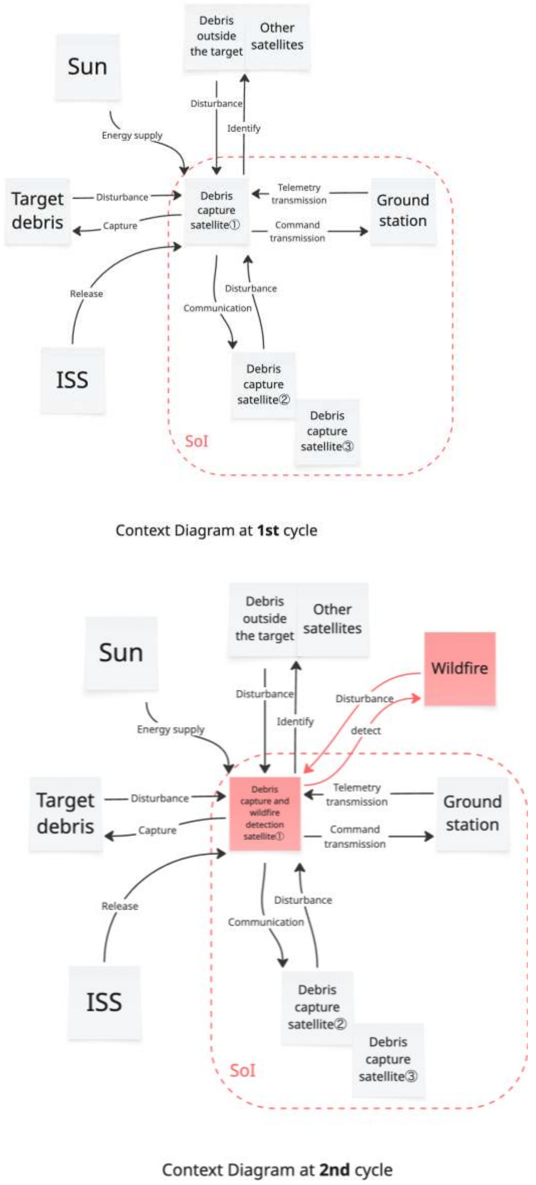

Figure 3. Context diagram results from the first and second cycles (differences in the second cycle are highlighted in red).

Table 1. Use case descriptions from the first and second cycles.

Use Case	Use Case Description
Satellite Deployment	ISS releases the satellite / Satellite turns on power
Communicate with Ground	Satellite transmits telemetry / Ground station receives telemetry / Satellite checks health status
Observe Forest Fires	**Satellite observes forest fire / Satellite downlinks wildfire information(Added in 2nd cycle)**
Search for Debris	Ground station sends search start command / Satellite receives command / Satellite starts search / Satellite transmits radio waves / Satellite observes an area
Identify Target Debris	Satellite identifies debris to capture
Capture Debris	Satellite starts debris capture / Approach debris / Satellite performs attitude control / Satellite captures debris / Satellite secures debris / Satellite downlinks captured object / Ground station receives video

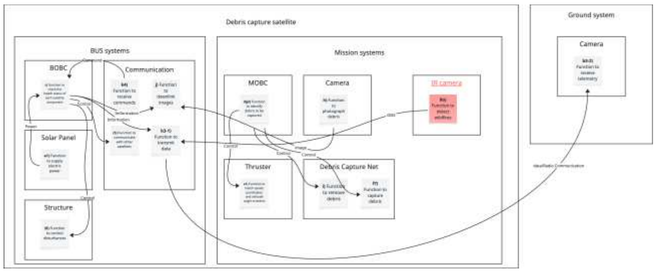

Figure 4. System diagram results from the first and second cycles (differences in the second cycle are highlighted in red).

Following the analysis of deliverables, the rubric evaluation focused on goal orientation, which was the primary objective of the workshop. Figure 5 shows changes in goal-orientation scores by team, with the vertical axis representing rubric scores (0–3) and the horizontal axis showing the exercise stages (0: before the first attempt, 1: after the first cycle, 2: after the second cycle). Each line represents an individual participant, and the legend indicates the academic year. Participants' free-text comments at each stage were analyzed using content analysis, and the three most frequently mentioned themes were extracted (Table 4). Numbers in parentheses indicate the number of respondents for each theme.

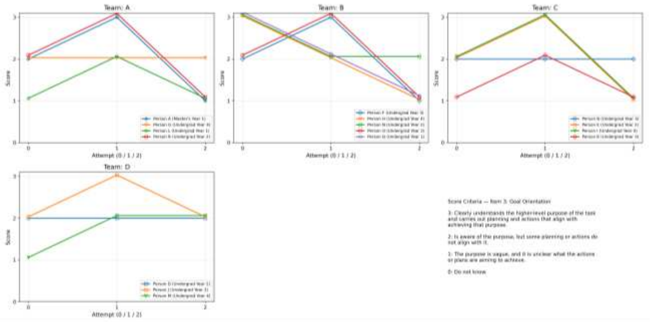

Figure 5. Changes in rubric self-assessment scores for goal orientation by team.

Table 4. Top three themes from free-text comments related to goal orientation at each stage (numbers in parentheses indicate total number of responses).

Stage	Top 3 Themes (No. of Participants)
Before 1st Attempt	Prioritizing preferred tasks over necessary ones (3), Difficulty in planning and execution (3), Aware of the purpose but actions or plans are misaligned (2)
After 1st Cycle	Linking requirements/specifications to the purpose (4), Returning to requirements or function extraction (4), Confusing means with the purpose (2)
After 2nd Cycle	Focusing on immediate tasks after new mission assignment (6), Linking requirements/specifications to the purpose (3), Confusing means with the purpose (3)

After the first cycle, themes related to goal orientation—such as linking requirements and specifications to purpose and returning to requirement extraction—appeared more frequently. After the second cycle, the most common theme shifted to focusing on immediate tasks following the new mission assignment, while references to goal orientation decreased.

Following the workshop, a brief post-event survey was conducted to assess participants' perceptions. All participants (n = 10) reported understanding both the methods and the rubric. Reviewing the rubric supported understanding (before the workshop: 70%, after the workshop: 90%). Improvement in understanding of Systems Engineering (SE) was reported by 90% of participants, both compared with before using the rubric and compared with before the workshop.

5. Discussion

This workshop yielded several insights into the use of rubric-based self-assessment and the instructional design of Systems Engineering (SE) education aimed at cultivating goal orientation—a competency regarded as essential for applying Model-Based Systems Engineering (MBSE) effectively. The two-cycle structure was deliberately designed to create contrasting cognitive conditions. In the first cycle, participants followed guided instructions and used the rubric to consciously align their design actions with mission objectives. In the second cycle, an additional mission requirement ("wildfire observation") was introduced, and participants worked autonomously without explicit guidance. This contrast intentionally increased cognitive load, encouraging participants to experience both the strengthening and the disruption of goal orientation.

The resulting pattern—an increase in rubric scores after the first cycle and a decline after the second—was consistent with the instructional intent. Qualitative comments further revealed that participants often became preoccupied with achieving given requirements ("fire detection") and lost sight of higher-level objectives such as "saving lives" or "fire suppression." Such purpose drift reflects a well-documented phenomenon in complex engineering tasks, where procedural goals gradually replace strategic or value-oriented objectives. Educationally, this controlled disruption allowed participants to recognize and reflect on their own cognitive tendencies, fostering metacognitive awareness of how design reasoning can deviate from original intent under pressure or uncertainty.

To deepen conceptual understanding, the workshop introduced three analytical perspectives—spatial, temporal, and semantic axes—to structure reflection. The spatial axis addressed the relationships among system elements; the temporal axis captured process dynamics; and the semantic axis emphasized the rationale linking "why," "what," and "how." The second cycle's mission change was intended to shift the semantic axis, prompting participants to realize that altering purpose redefines both the System of Interest (SoI) and its surrounding context. However, most teams did not fully articulate this relationship. In the debriefing discussion, facilitators demonstrated that adding wildfire observation expanded the SoI to include data processing and ground-based coordination, illustrating how shifts in mission purpose propagate through system boundaries and design logic. This reflection helped participants grasp that goal orientation is not static but must be reconstructed through continuous reasoning across multiple dimensions.

Overall, the findings suggest that purpose-driven SE practice can serve as an entry point to MBSE thinking, enabling learners to interpret design not only procedurally but also structurally and semantically. The results align with INCOSE (2022) and Busch et al. (2024), who emphasize that model-based reasoning requires explicit, traceable articulation of design rationale. Even without formal MBSE tools, this workshop demonstrated that model-based thinking—reasoning about relationships, trade-offs, and justification—can be cultivated through reflective SE exercises. Continuous reflection on purpose thus represents a cognitive foundation for developing both goal-oriented and system-oriented mindsets central to MBSE education.

6. Conclusion

This study implemented and examined an introductory Systems Engineering (SE) workshop situated within a broader MBSE-based educational program. The workshop aimed to cultivate goal orientation—the ability to maintain and reconstruct a clear sense of purpose throughout the design process—as a foundational competency for future Model-Based Systems Engineering (MBSE) practitioners. Through a two-cycle exercise employing rubric-based self-assessment and structured reflection, participants experienced both the strengthening and the disruption of goal orientation, providing an opportunity to observe how design intent can shift under changing conditions.

The findings from this small-scale implementation with 18 participants suggest that purpose-driven SE practice may serve as an effective entry point to MBSE thinking. Rubric scores and qualitative reflections indicated that participants often shifted from higher-order mission objectives to procedural tasks, illustrating purpose drift commonly observed in complex design contexts. However, reflective discussions encouraged participants to recognize these lapses and to reconstruct their understanding of purpose as a structural and semantic driver of system design.

While the workshop results are preliminary, they suggest the potential effectiveness and feasibility of introducing goal-orientation training within SE education as a preparatory stage for MBSE practice. These findings imply that model-based reasoning—the cognitive foundation of MBSE—can be nurtured even in tool-free, conceptual SE exercises through structured reflection and dialogue. Future research will expand this investigation by incorporating MBSE tools and full lifecycle modeling processes, such as requirements definition, functional structuring, and design validation, to explore how purpose awareness evolves as learners transition from conceptual reasoning to model-based implementation.

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References

Akundi, A., Ankobiah, W., & Agrawal, A. (2024). Mapping industry workforce needs to academic curricula – A workforce development effort in MBSE. Systems Engineering, 27, 34–46.

Bajczi, L., Szekeres, D., Siegl, D., & Molnár, V. (2024). Enhancing MBSE education with version control and automated feedback. arXiv preprint arXiv:2409.15294.

Busch, A., Dreisbach, R. L., & Popielas, F. (2024). What do simulation engineers need to know about systems engineering and MBSE. NAFEMS–INCOSE Systems Modeling and Simulation Working Group Report.

Dalal, M., Carberry, A., & Archambault, L. (2021). Developing a ways of thinking framework for engineering education research. Studies in Engineering Education, 1(2), 108–125.

Fernández, J. L., & Moreno, G. (2016). MBSE for engineering students. INCOSE International Symposium, 26(1), 1231–1245.

Greene, M. T., Papalambros, P. Y., & McGowan, A.-M. R. (2017). Design thinking vs. systems thinking in engineering design. In Proceedings of the 21st International Conference on Engineering Design (ICED) (pp. 367–376). Vancouver, Canada.

Hill, T. R., Nicoli, P., Pierce, G. J., Woodham, K., & Gati, F. (2024, March). Digital transformation of the NASA engineering domain. In 2024 IEEE Aerospace Conference (pp. 1–15). IEEE.

Hill, T. R., Carnevale, A. E., Morris-Eckart, A., Sundaram, V., & Farhaj, L. Z. (2024, July). NASA's use of MBSE and SysML modeling to architect the future of human exploration. In INCOSE International Symposium, 34(1), 527–543.

Inoue, M., & Hasegawa, H. (2010). Systems engineering education based on evolutional project-based learning [in Japanese]. Journal of JSEE, 58, 89–94.

International Council on Systems Engineering (INCOSE). (2022). INCOSE Systems Engineering Competency Framework (Version 2). International Council on Systems Engineering.

International Engineering Alliance (IEA). (2021). Graduate Attributes and Professional Competencies (Version 4). International Engineering Alliance.

Lorenzo Alvarez, J., de Koning, H. P., Fischer, D., Wallum, M., Metselaar, H., & Kretzenbacher, M. (2018). Best practices for model-based systems engineering in ESA projects. In 2018 AIAA SPACE and Astronautics Forum and Exposition (p. 5327). AIAA.

Reichwein, A., & Paredis, C. J. J. (2011). Overview of architecture frameworks and modeling languages for model-based systems engineering. In ASME 2011 International Design Engineering Technical Conferences (Vol. 2, pp. 1341–1349). Washington, DC, USA.

Salado, A., McDermott, T., Davis, K., & Moral, A. (2019, June). Why not teaching systems architecture as a studio art class? In Systems Engineering in Context: Proceedings of the 16th Annual Conference on Systems Engineering Research (pp. 267–278). Springer.

Tanaka, K., Ito, T., Inomata, R., Akiyama, H., Kogiso, N., Aoyanagi, Y., & Shirasaka, S. (2025). An overview of the development plan for a space architect training program utilizing MBSE. In Proceedings of the 35th International Symposium on

Space Technology and Science (ISTS 2025).

ESA MBSE Working Group. (2022). Concurrent engineering and MBSE training programs at EPFL. European Space Agency.

University of Arizona, Department of Systems & Industrial Engineering. (n.d.). SIE 558: Model-Based Systems Engineering. Retrieved August 12, 2025, from https://sie.engineering.arizona.edu/course/sie/558

Yamasaki, M., Sakamoto, H., Sato, K., & Kawakami, S. (2023). Model-based systems engineering education with CubeSat education kit "Hepta-Sat LITE." In Proceedings of the 37th Annual AIAA/USU Conference on Small Satellites (SSC23-WKVIII-04). Logan, UT, USA.

Biography

Kohei TANAKA

Kohei Tanaka is a Project Senior Assistant Professor at the Graduate School of System Design and Management (SDM), Keio University, Japan.

He received his Ph.D. in Engineering from the Graduate University for Advanced Studies (SOKENDAI) in 2017, his Master's degree in Systems Engineering from Keio University in 2013.

Before joining Keio, he worked as a space systems engineer at Canon Electronics Inc., contributing to the development of microsatellites.

His current research focuses on Model-Based Systems Engineering (MBSE), systems architecture design, and assurance-case-based approaches for ensuring reliability in complex space systems. He also leads educational programs for training "space architects" who integrate systems engineering, project management, and design thinking to address interdisciplinary challenges.

Tsubasa ITO

Tsubasa Ito is a Project Assistant Professor at the Graduate School of System Design and Management, Keio University.

After completing his undergraduate studies, he worked at NEC Nexsolutions, Ltd., where he engaged in the development and implementation of enterprise resource planning (ERP) systems. He received his Master's degree from the Graduate School of SDM, Keio University, and has held his current position since 2022.

His research focuses on system design for human-centered innovation. A product developed by his team for preventing olfactory decline received international recognition, winning design awards in five countries. Since 2023, he has also served as a Digital Advisor for the Ministry of Land, Infrastructure, Transport and Tourism of Japan.

Ryoya INOMATA

Ryoya Inomata is a Project Assistant Professor at the Graduate School of System Design and Management (SDM), Keio University, and Director of JISSUI.

He received his Bachelor's degree from the Faculty of Science and Technology, Keio University. During his undergraduate studies, he founded a web venture, and after leaving the company, he worked in business planning at a precision equipment manufacturer. In 2018, he completed his Master's degree at the Graduate School of SDM, Keio University.

He currently serves as Director of JISSUI, where he oversees government-funded projects and supports startup-related initiatives. His research focuses on customer value design in startup companies, as well as engineering and entrepreneurial education.

Seiko SHIRASAKA

Seiko Shirasaka received his Master's degree in Astronautics from the University of Tokyo in 1994 and a Ph.D. in Systems Engineering from Keio University in 2012.

He is a Professor at the Graduate School of System Design and Management, Keio University, Japan, and one of the Founders of Synspective Inc., a company providing SAR satellite data solutions.

Before joining Keio, he worked as a space systems engineer at Mitsubishi Electric Corporation.

He also served as a Program Manager for the Japanese government's ImPACT program from 2015 to 2019.

His research focuses on systems engineering and model-based approaches for complex system development.