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Systems Engineering in university education with focus on Systems Thinking

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Abstract

Systems Engineering (SE) is a growing field that has also repeatedly found points of contact in teaching for many years. The global and societal challenges we face today can be met with technical solutions. This requires an interdisciplinary and systemic approach, which is firmly anchored in SE. SE can be seen as problem-solving process that includes the SE principles System Thinking and Process Model as well as Methods and tools in the field of Systems Design and Project Management. Especially in university education, SE has become an important facet in the technical fields. In German universities, Systems Engineering is taught in modules, and in some cases entire courses of study can be found in this area. The focus is on the development of technical systems, and thus technical competencies are often addressed in the foreground and deepened depending on the faculty. Immediate factors such as Systems Thinking, collaboration and communication, and project management are not explicitly addressed, although they are considered essential. In this paper, we analyze the need for action, show examples from teaching, which give a deeper insight into the chosen approaches through publications. Afterwards, we show our own approach, which was designed and implemented for online teaching, partly due to the ongoing pandemic. The aim of the approach is to provide students not only with basic knowledge but also with a set of methods that enable them to approach the problem-solving process systemically, and systematically. Through exercises, methods do not remain theoretical - they show their effect in which students take diverse views of the system, enter into technical discourse about the system (communication) and thus understand the system as well as its process of creation. In this article, we present the concept and report on the experiences during the implementation, critically reflect on the approach and derive further action steps.

Keywords: Systems Engineering, Systems Thinking, education, complex systems, competencies

1 Introduction

"Engineering solutions for a better world" – this is the title of INCOSE's motivation for the established Vision 2035. Systems Engineering is a key to the design of these solutions. In this context, Systems Engineering must not be understood as a new discipline, but rather as a basic concept that connects the actors involved in designing the solution and approaches tasks in a holistic way. What Systems Engineering entails and what competencies the engineers of today and especially tomorrow will need are derived in the vision and listed in the following areas (*Systems Engineering Vision 2035*, 2021):

1. Core Systems Engineering Principles
2. Professional Competencies
3. Technical Competencies
4. Systems Engineering and Management Competencies
5. Integrating Competencies

The look at the curricula of technical faculties in Germany, we observe two phenomena: The faculties are strictly separated according to subject areas and find it difficult to teach interdisciplinary. Systems Engineering is thus anchored within these faculties (electrical engineering, computer science or mechanical engineering). Along with this, the focus also goes in the discipline-specific direction: in electrical engineering – hardware design at system level; computer science – software architecture at system level; mechanical engineering – design at system level. The second phenomenon is the focus on the technical competencies – Requirements Engineering, System Architect, Design for Sustainability and Manufacturing. A core from Systems Engineering: Systems Thinking, Critical Thinking, and Design Thinking are largely not explicitly focused. The ability of thinking is not trainable by knowledge, but it needs experience to develop and train this skill. These partly soft competencies are reluctantly seen and downplayed as real teaching areas in technical fields. However, it is these competencies meet the challenges in today's world (Weiß, 2017).

2 Systems Engineering and Systems Thinking

Technical systems are becoming increasingly complex and are developing into Cyber Physical Systems. They are interconnected, form new Internet-of-Things solutions, and are thus always part of a system of systems. The development of such systems can no longer be done by just one technical discipline, but requires the interaction of a wide variety of fields. The new challenges that arise are growing interdisciplinary and increasing complexity in the design of these systems (Dumitrescu et al. 2020). In order to meet most of these challenges, well-trained specialists are needed who, in addition to technical knowledge, also have competencies in the field of Systems Engineering. Furthermore, industry demands special social competencies as well as the ability to think in interdisciplinary structures and to find creative solutions (Mäkiö, 2017; Advanced Systems Engineering 2021).

Systems Engineering

Systems Engineering is a rapidly growing field that has many facets and includes a strong community. Internationally, INCOSE stands for the representation of interests, for unification as well as for strategic orientation. The regional offshoots, such the German Society for Systems Engineering (GfSE), have formed in recent years and show an increasing number of members. But also in German research, a growing attention shows up, which is expressed by publications like the Advanced Systems Engineering Study (Advanced Systems Engineering 2021).

Systems Engineering theories and approaches are comprehensively described in technical books and standards. The actual situation is the dissemination and the experiences in industrial implementations, which raises new research questions and shapes fields of action (Nielsen et al., 2015; Wilke et al., 2021). New trends such as artificial intelligence, additive manufacturing or the way we work also have an impact on the systems themselves and thus on the way they are realized. Thus, Systems Engineering in its entirety is becoming thematically broader and difficult for outsiders to grasp. One explanatory is the concept of a "Systems Engineering manikin" according to Haberfellner et al.which is shown in Figure 1 (Haberfellner et al., 2019).

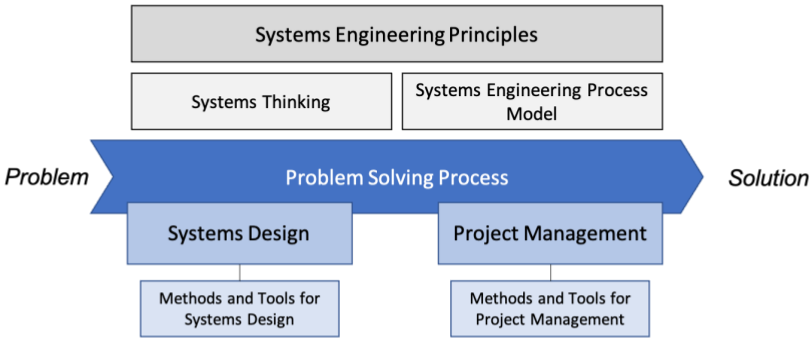

Figure 1: Systems Engineering concept by Haberfellner et.al.

Systems Engineering is a problem-solving process that includes both project management and systems design, and uses techniques from both fields to shape the solution. The Systems Engineering principles, which are expressed in Systems Thinking and in the process models, are of overriding importance. (Haberfellner et al., 2019) They make the difference in acting in a systemically (holistic view on the system) and systematically (guided through a process model from abstract to concrete) way.

Systems Thinking

The concepts of Systems Thinking were formed in the 1960s. It was recognized that the challenges society faced were so complex and fundamental that they could not be solved by discipline-specific approaches and linear processes. (Kay, 1999; Meadows, D. H. 2008)

Over the years, many definitions of Systems Thinking have been proposed. Most definitions include features like a comprehensive and holistic view of a problem, recognition of interdependencies and feedbacks, synthesis as well as analysis of individual components, and consideration of dynamic nonlinear behavior of systems. (Kay, 1999; Rehmann et al., 2011; Vanasupaa et al., 2008)

Systems Thinking is an outstanding characteristic for understanding and communicating complex issues and their dynamic interrelationships. There are different concepts available to deal with complexity. Haberfellner et al explicitly mentions the model-based approach as a basis for Systems Thinking. With models there is always an abstraction, a shortening and a purpose limitation (Stachowiak, 1980). In order to understand systems in their entirety, different views must be taken. Here Haberfellner et al defines the environment-oriented, the effect-oriented, the structure-oriented as well as the dynamic view (Haberfellner et al., 2019). Systems thinkers use tools and methods that enable them to identify difficulties in these systems and think about ways to (re)design the systems. Systems Thinking helps to recognize that there is often not a single solution to a problem, but a series of coordinated actions that steer the system toward a desired state or outcome. (Betley et al., 2021)

That’s why Systems Thinking becomes a core competence. However, each competence must be developed over years. Therefore, systems thinkers also need to train this competency in order to grow habits that support the development of technical systems. Due to the change of the way we will work and develop systems, new aspects must be taken into account in the training of future engineers (*Advanced Systems Engineering*, 2021; Weiß, 2017):

- Teaching in an interdisciplinary context
- Teaching methods to develop Systems Thinking competence
- Help to build up a set of methods to enable different views of a system

3 Teaching concepts

Since Systems Engineering and Systems Thinking can be identified as essential competencies for future engineers, existing teaching concepts are summarized in this section. This is an exemplary selection of approaches that illustrate the different emphases and solutions in university education. They do not claim to be exhaustive.

3.1 INCOSE Systems Engineering Curriculum

One approach to teach Systems Engineering at universities comes from Jain et al. The authors first conducted a study of different Systems Engineering programs at 36 universities in the U.S. and Europe. They then matched these programs with industry and government requirements and developed a reference curriculum. This study was initiated in response to a request from the Academic Council of INCOSE and supported by the Systems Engineering Curriculum Working Group within INCOSE. One of the main goals of the reference curriculum approach for Systems Engineering is to attempt to bridge the gap between the Systems Engineering competencies expected by potential employers and the curricula of Systems Engineering degree programs. The framework is intended to support the development of new systems engineering degree programs and the enhancement of existing degree programs. The proposed approach has the following three dimensions: Subject Areas, Levels, and Systems Engineering Competencies. With the help of the study, it was found that the three competencies of systems concepts, architectural design, and modeling and simulation are not sufficiently addressed in universities but are required by industry. The proposed curriculum uses a four-tiered approach that begins with a foundation in mathematics and introductory courses and progresses to core Systems Engineering courses supplemented by advanced and specialized courses (Figure 2).

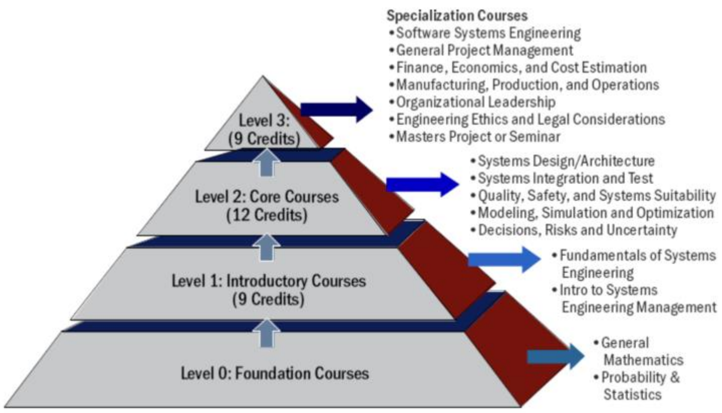

Figure 2: Framework Systems Engineering curriculum (Jain et al., 2007)

The recommended framework consists of a basic framework of sixteen systems engineering topics and related subjects that universities should consider when developing a curriculum, depending on the level of study. (Jain et al., 2007)

3.2 Industry-oriented approach in Germany

Systems Engineering as a separate course of study is offered by the German universities of Augsburg, Kempten and Neu-Ulm. The universities developed a joint concept in 2014 as part of the "University and Region Partnership" competition, which addresses current challenges. The program is designed to enable students to have continuous contact with industry and thus study while working. This not only supports the students, but also the industrial companies, which are located in rural regions and often lose employees to companies that are close to the universities. In terms of content, the degree program was designed to meet the needs of regional industry. The change taking place in the economy towards digital production was taken into account. The main focus here is on the challenge of networking various players in order to optimize processes while resources are becoming increasingly scarce. The program is a combination of engineering and computer science. The goal is to optimally prepare students for the requirements of digitalization in industry. The teaching concept contains several phases. In the orientation phase, engineering fundamentals are taught, and key competencies are strengthened. This phase is characterized by a high level of presence in the companies, individual learning phases with digital teaching and learning opportunities, intensive personal support, and networking through joint projects. This is followed by the in-depth phase, in which the topic of Industry 4.0 is addressed. This phase also contains a high proportion within the companies. Since the students are not only involved in the companies in short phases, there is the possibility of integrating them into long-term projects. In order to achieve a high practical portion in the studies, project modules are integrated in each semester, in which the contents from the theoretical modules are applied. In order to create added value in the region, industrial companies can create real tasks. In the Systems Engineering course, the contents are taught via different media. There is an e-learning management system (Moodle), as well as a video-conferencing system and a messaging system that students can use to exchange information. (Klever et al., 2017)

3.3 Soft competencies in a Systems Engineering master program

Another concept comes from Paetzold et al. A concept for a part-time course of study was developed, which sees technical knowledge as well as knowledge of relevant technologies as a prerequisite. Building on the bachelor's degree, the master's program deepens this knowledge, building relationships between the basic knowledge to describe more complex issues. Students learn to think more in terms of processes and interrelationships. The concept developed is not intended to impart technical knowledge, but focuses on viewing complex systems from different perspectives. The aim is to analyze complex technical systems and complex decision-making situations in order to draw conclusions for the synthesis process and to master complexity. The course has three objectives:

1. An understanding of the complexity of a technical system must be built up. To do this, it must provide not only knowledge of processes and methods, but also practical problems in the context of systems engineering.
2. On the basis of an understanding of systems and processes, tasks of systems engineering management are worked out and approaches to solutions are discussed.
3. The students should be enabled to transfer and apply the basic knowledge in the field of Systems Engineering to real problems from their professional practice in the company, the industry etc.

The teaching program is divided into three blocks: Basic Courses, Advanced Courses and Practical Phase. The tasks in the field of Systems Engineering are very heterogeneous. Solution approaches depend on the industry, market, product spectrum, competitive environment and other aspects. The practical modules give students the opportunity to learn about solution approaches and best practices from different domains, and to apply them to similar tasks and problems in other areas. Issues from the students' professional environment are taken up and analyzed with the aim of deriving concepts for dealing with the problems. Students are intensively involved in the preparation of the modules. Papers and presentations are part of the examination. The attendance phase is organized as a workshop, not only to support knowledge building, but also to find solutions for current concerns. Presentations by speakers from industry complement these lectures. This principal structure makes it possible to incorporate the wishes and needs of the participants into the module. In order to convey the contents and to design the courses, Paetzold et al. uses combined learning, which is a didactic concept. It is characterized by the fact that it is a combination of e-learning and face-to-face events. (Paetzold et al., 2015)

Conclusion

The described approaches intend to close the gap between existing teaching programs and the required competencies from industry. In this context, it is clear that the focus is primarily on technical topics. Soft topics, such as teamwork, interdisciplinary, communication and individual learning, are implicitly addressed on in the approaches considered. Especially Paetzold et al. focused on the soft competencies. Another gap that has received little attention is the advancing digitalization. Especially due to the Corona pandemic, universities and industries are in need of digital approaches. However, only a few approaches consider digital learning. It should be noted here that the concepts were developed before the pandemic and may have adapted to the circumstances, taking into account aspects such as digital learning. In general, it is clear that practical relevance to the topics plays a crucial role. Through direct application in practice, what is taught is internalized and students have a higher motivation.

4 Own Approach

This section presents our own approach. First, we look at the framework conditions that had to be taken into account before the course concept was built. Afterwards, we go into the learning objectives and present the elements that were chosen to achieve these. The course is integrated into the modules of the technical master's programs of the Technical University. These include Mechanical Engineering, Computational Engineering Science, Production Engineering, Vehicle Engineering, Transportation Planning and Operation.

The impact of the Covid-19 pandemic shifted teaching to the digital since summer semester 2020. Students already knew one year of teaching in digital form, which manifested itself in various ways. The concept was conceived and implemented for the summer semester of 2021 as part of the new department Digital Engineering 4.0 at the Technische Universität Berlin.

4.1 Goals of the course Systems Engineering

The module addresses four major goals. To achieve these goals, learning units are defined, which in turn are refined into sub-goals.

Acquire basic concepts and terminology of Systems Engineering

Students should learn basic terms, history, basic concepts and theories of Systems Engineering and expand their own vocabulary with important technical terms. These should be used confidently by the end of the semester.

Apply and reflect knowledge

The students should put the knowledge they have learned into context, link it to their previous experience, and reflect on it together. In doing so, they should apply what they have learned to an example. In this way, what has been learned should be consolidated, and new insights gained.

Training Systems Thinking

Over the course of the semester, students are given methods to apply to the common example. The methods are to be understood and reflected upon at their core so that they can be applied to other examples. With the application of the methods, diverse views of the system are explicitly taken and thus Systems Thinking is trained.

Understanding Systems Engineering as a Field of Research
Students will engage in discussion and critical reflection over the semester. This is to raise questions that develop a sense that this is a research field that continues to be explored and shaped. By looking at published research findings, students will learn about, understand, and reflect findings from this field of research.

4.2 Elements and contribution to goal achievement

Essentially, the course consists of asynchronous and synchronous components as shown in Figure 3. The synchronous sessions take place via Zoom and are complemented by a virtual whiteboard for collaborative interaction. The asynchronous learning content is stored on the Moodle platform and can be acquired by the students independently, in their own time. These include the following course units: *Basic Concepts in Systems Engineering, Challenges in Designing Cyber Physical Systems, Systems Thinking, Requirements Engineering, Systems Architecture, Model-Based Systems Engineering, Processes and Procedures, Implementation of Systems Engineering;* and addresses the first objective of *Acquiring Basics and Terminology.* This is supplemented by a common glossary, which is continuously filled by the students. This glossary contains important terms and thus ensures a uniform understanding of the technical terminology used.

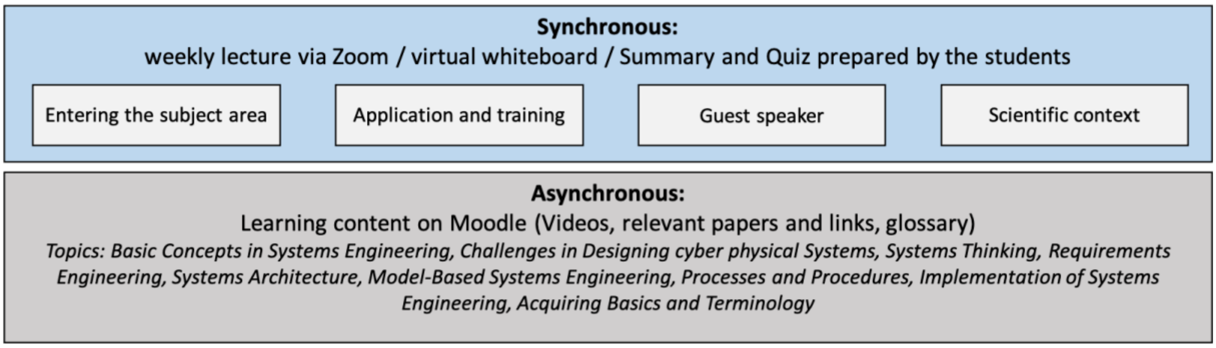

Figure 3: Teaching concept Systems Engineering at Technische Universität Berlin

In groups of two, the learning units are summarized for each synchronous date and processed in a quiz. In this way, the knowledge is compactly prepared, repeated and tested in a playful way. The quiz has two effects: The students who prepare the quiz deepen this learning unit, as they deal with closed questions and alternative answers. The quiz participants, in turn, can check whether they have understood and internalized what they have learned.
The synchronous Zoom-meetings are divided into four phases:

1st Phase: Getting to know each other and entering the subject area
The students from the various (technical) master's programs are characterized by the fact that they have different focal points and therefore bring diverse perspectives with them. In addition, the students have initial practical experience, either through training or through student activities at companies or research institutes during their studies. These experiences and perspectives are the basis for the first exchange. Therefore, getting to know each other is an important first step. This is done in reflection with the first learning units on the basics of Systems Engineering, Cyber Physical Systems and Product Development Processes.

2nd Phase: Application and training
In the second phase, which extends over 8 of 14 dates, the application of individual methods takes place on an example system. In this case, the robot COZMO from Dream Labs was selected. As an autonomously acting system, COZMO can interact with its cubes, move freely

on a surface, recognize animals and people, and interact. The system is available in the market in the form and is not to be redeveloped by the students. It is much more about looking at this system from different perspectives. For this purpose, methods are used that enable this perspective. Thus, the students learn the method, apply it in small groups and deal with the system more and more. Over time, students gained insight into several methods. This set of methods serves as a tool for training Systems Thinking and is applied to other examples in the examination phase. The views and the methods used are listed below. Students work in small groups and apply the methods. This was implemented with a virtual whiteboard, on which all results were developed interactively over the semester. Figure 4 shows a part of the results.

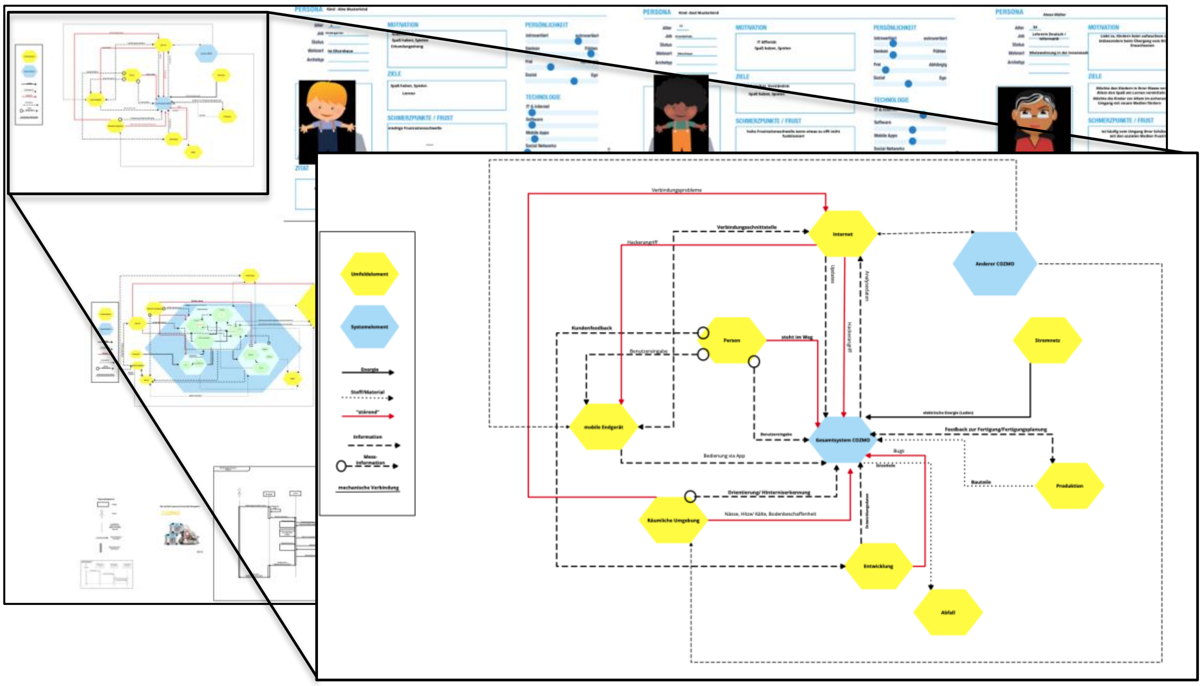

Figure 4: Section of the virtual board with a context analysis and Personas

During the exercises the different views defined by Haberfellner et al. were focused.

- *Environment-oriented view:* The black-box view is achieved by methods such as environment/context analysis, personas and mind-map. Via the mind-map, all facets to be considered in the design of the system are collected and presented. Stakeholder and in-depth consideration of the personas provides a view of the system from the user perspective. What are the needs and desires of the users, how do they use the system and what do they value? The context analysis itself shows the interfaces that the system must provide in order to operate in its environment. During this time the group discuss the systems boundary to have a common understanding what is the system they are looking at.

- *Impact-oriented view:* The impact-oriented view is still a black-box view but now focuses on the inputs and outputs of the system. This can be achieved through use cases or a functional decomposition. Students learn to think in terms of the product life cycle. A use case illustrates how the system is used in this cycle phase. In addition, explicit misuse cases were considered in order to take into account unintentional handling and to derive measures.

- *Structure-oriented view:* This view is the static view of the system. By the structure-oriented view of the system hierarchy, the system elements and their interactions are regarded. With this view, an interdisciplinary, holistic view of the system is possible. From this point, students get an understanding of the elements of the system and their principles of interaction.

- *Dynamic-oriented view:* Despite the principles of action, the structure-oriented view does not capture the behavior of the system. This is part of the dynamic-oriented view. Temporal aspects and logical sequences represent the system behavior. This is described with sequences, states and activities.

Each step shows a new perspective of the system, so that the big picture grows. From the diverse points of view requirements can be derived easily. These are initially recorded and uniformly described with the help of templates. The students also show which method serves as the "source" of this requirement. The interrelationships between the various views are continuously queried, thus creating an awareness that the methods are not to be viewed loosely, but rather that dependencies prevail, which must also be recorded. As an extended task, the groups are confronted with a "development assignment" for COZMO. With this, they learn to use the results, to make changes to the system transparent and to use them for tracking.

3nd Phase: Guest speakers (industry contributions)
In the third phase, students gain insight into how Systems Engineering is viewed and treated in companies. This provides an additional practical reference. Theories and methods can easily be used without a corporate context, as many dimensions are hidden. In teaching and research, this is exactly what happens. Thus, methods and approaches often fail as soon as they are applied in a company. Time pressure, interdisciplinary, excessive demands, untrained soft skills, outdated IT landscape, lack of appreciation are exemplary aspects that make dissemination difficult. Guest speakers from companies contribute this perspective. They show from their point of view, with which motivation the companies come to Systems Engineering, how the company interprets Systems Engineering, how they approach the topic company-wide and which methods and tools are used.

4th Phase: Systems Engineering in the scientific context
In the last common block, students are assigned standards and scientific contributions. Students work independently in teams of two and design 30 minutes of lecture time. Students can organize this time individually with the goal of reproducing content, linking it to the learning content, as well as interacting with fellow students. This gives students an insight into research work in the context of Systems Engineering.

The grade from the course has consisted of oral consultation and a presentation in the field of *Systems Engineering in the scientific context.* Furthermore, the students had the chance to get bonus points by active participation and the preparation of a summary. In the oral feedback, it was required that the students can use technical terms confidently as well as reproduce and transfer knowledge. The fact that students had more time to apply the methods in the second run had a positive effect on the average grade. Furthermore, the students were very motivated to get bonus points and thus consolidated their knowledge through summaries and quizzes.

Developing the course, existing elements from the approaches described in chapter 3 were used and partly adapted. Much attention was paid to the exchange and social competencies, similar to Paetzold et al. approach. Furthermore, the competence of System Thinking was in the foreground. For this we used existing methods and especially the different perspectives according to Haberfellner et al. Students take an essential part in shaping the course by presenting and teaching content and sharing experience.

5 Results from the course and voices of the students

In this section, we present results as well as the learning outcomes based on a survey. After the SE course, we asked students to complete a questionnaire about the course, which helps to reflect on the progress in Systems Thinking and to derive potential improvements for the course. A total of 13 students from different master programs who took the Systems Engineering course in the summer semester 2021 and winter semester 2021/2022 participated in the survey. The results are not representative but show student's perspective of the course. In the survey, we gave students the opportunity to suggest improvements to the course and share other opinions on the subject matter. Table 1 shows some quotes from the survey.

Table 1: Voices of the Students

Feedback to the course	Thoughts to share
"I really enjoyed the course and, in my opinion, it was nearly perfect. I think Cozmo was a good example to understand SE and its principles. For the next courses I would continue with this type of project work because this supports the cooperative work in a team and systems thinking. " "Give more examples about current research in SE and more examples (if there are any!) about applications of SE in companies. " "Discuss bigger problems on a surface level, for example the mobility or energy crisis. Systems like *personal mobility in Germany* cannot be fully grasped in one course, but in my opinion, they allow the application of SE concepts with great success and also show the necessity for it, this would make learning about the benefits of these approaches easier in the beginning before approaching specific technical products, where solutions seem more apparent"	"Very important topic and that is also why it is pretty sad that it is not a mandatory course " „Systems Thinking and Systems Engineering shall be used in projects to fully understand it. Learning it theoretically is a good start but it is not enough. " "Systems Thinking and interdisciplinary teamwork should be part of every mechanical engineer's education." "I think it is one of the most useful things I have learned throughout my studies. " "I really enjoyed participating the course. SE is now a fundamental part of my knowledge as an engineer, which might be very helpful in the future. " "Engineering is a tool for real life problems. Systems Engineering is a tool for engineering problems. "

At the end, the students have indicated that all learning objectives have been at least partially achieved. Here, the goal *Acquire basic concepts and terminology of Systems Engineering* was evaluated as fully achieved by all students. The second objective *Apply and reflect knowledge* was rated as fully achieved by 10 students, 3 students partially achieved this objective. *Understanding Systems Engineering as a Field of Research* was fully achieved by 9 respondents and partially achieved by 4. The goal to *Train Systems Thinking* was fully achieved by 6 respondents and partially achieved by 7. Although the goal to train Systems Thinking was fully achieved by only 6 respondents, a great improvement in Systems Thinking was observed, as shown in Figure 5. After the course 8 students rated their Systems Thinking ability as advanced. Before the course, there were 3. Before the course, no student rated themselves as very good at Systems Thinking. After the course, very good Systems Thinking was indicated by 2 students.

In the survey, students were also asked if they continued to use Systems Thinking after the course and if so, in what areas. 9 of the 13 participants indicated that they also use Systems Thinking in their personal lives and especially at work. We also asked the students about the relevance of the ability of Systems Thinking for engineers. All participants stated that they consider Systems Thinking to be an important ability of all engineers.

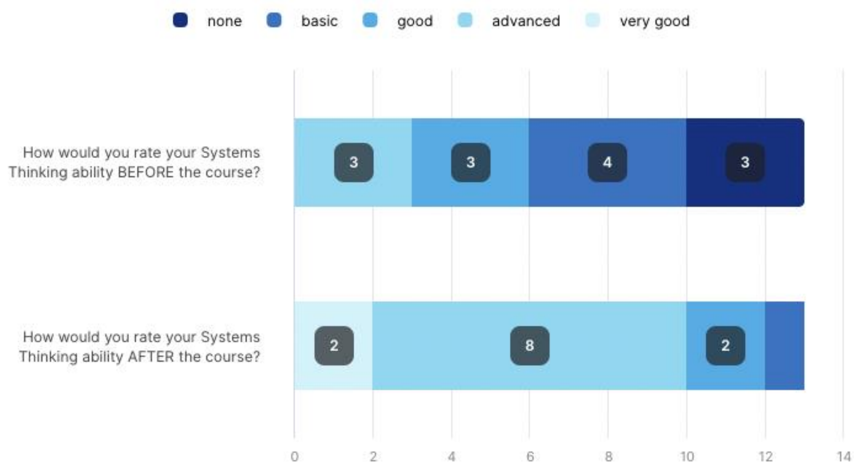

Figure 5: Development of Systems Thinking ability

6 Reflection and Outlook

The teaching concept described was developed in 2021 and took place twice in purely digital form. The number of participants was limited to 25, so that exchange and individual support were still possible. The first run-through showed quickly that the students were eager to get involved and share their perspective. It was surprising, but also enriching, that so many already had experience in companies or student project work. The time for method application was judged to be too short in the follow-up, so these appointments were increased from 1.5 h to 3 h for the second run in the winter semester 2021/2022. This change had a positive effect on the quality of the results. While the first run was only able to approach the methods, the second run was able to deal more intensively with the respective view of the system. In the module, a modeling tool was explicitly omitted in order to leave the peculiarities of the tools out of the equation. The method was thus brought to the fore.

The handling on the virtual whiteboard was a bit more cumbersome in some points, but everyone was able to work in parallel and got started very quickly. The group work in the purely digital form took place in breakout rooms in Zoom and showed its limits. An insight into the work was only possible afterwards during the joint discussion. It became apparent that a small group of people spoke up more often than others. As a lecturer, it was difficult to develop a feeling for the balance within the groups and to intervene if necessary. From this experience, a hybrid format will be sought in next runs. The asynchronous (digital) elements will be retained to maintain flexibility and the ability to view content multiple times and work through it at one's own pace. Group work will be conducted in a face-to-face setting. To this end, the aim is to bundle meetings and hold them in blocks. This is to ensure that the link between the methods is evident. The guest lectures were also rated very positively. The students gained a good insight into the company's approach and the challenges involved. The speakers are invited at the end of the semester. As a result, the students have already internalized the basics, were able to follow the contribution and ask well-founded questions. While the course focused on Systems Thinking and methodical work, it created a need for students to experience, practice and reflect on the application in real projects. Within this course, students were provided with a set of methods containing approaches to generate diverse views. Internalizing when which view is useful and how it is used in the creation process could not be addressed within the framework. Therefore, the next runs will focus even more on the Systems Thinking aspect. The basis for Systems Engineering and Thinking was laid in this course, which should be deepened by the students in further modules. For this purpose, two focal points are to be emphasized in the core:

Working with and on the models, and real-world application in an interdisciplinary project. In the future, this teaching concept must be further expanded. In general, teaching should move towards being location-independent, cross-domain and digital. Furthermore, the reference to industry and real issues should be established more intensively.

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