COMMUNICATION STRATEGIES FOR INTERDISCIPLINARY TEAMS THROUGH DESIGN THINKING AND TECHNOLOGY-DRIVEN PERSONALIZED LEARNING IN HIGHER EDUCATION

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Abstract: The paper discusses how Design Thinking (DT) and technology-enhanced learning can support multidisciplinary teams in Higher Education (HE), working on creative projects. In particular, it proposes the integration of Design Thinking and AI-driven technologies into educational methodology to improve communication, engagement, personalized learning, and interactivity. The intended results of this approach are to address one of the challenges faced by HE institutions consisting in developing students' creativity, appreciation of the learning process, critical thinking and problem-solving skills. This educational project is being designed in collaboration with the Department of Industrial Design and the Learning Mall at Xi'an Jiaotong-Liverpool University (XJTLU). The methodology includes literature review on DT, surveys collected from the Design School students at XJTLU, and the AI assistants. The integration of dynamic tools such as Articulate Rise 360 and AI has made it possible to visualize concepts and create interactive content for the learners. The results share two educational prototypes that introduce a new thinking model to Design Thinking methodology and share experiments with interactive technological features. By applying this approach, teachers can create an environment conductive to the development of skills needed in the 21st century.

Keywords: Design Thinking Model, 21st century skills, Technology-Enhanced Learning, AI, Interactivity, Creativity, Personalization

КОММУНИКАЦИОННЫЕ СТРАТЕГИИ ДЛЯ МЕЖДИСЦИПЛИНАРНЫХ КОМАНД С ИСПОЛЬЗОВАНИЕМ ДИЗАЙН-МЫШЛЕНИЯ И ПЕРСОНАЛИЗИРОВАННОГО ОБУЧЕНИЯ НА ОСНОВЕ КОМПЬЮТЕРНЫХ ТЕХНОЛОГИЙ В ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ

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Аннотация. В статье обсуждается, как дизайн-мышление и обучение, основанное на компьютерных технологиях, могут помочь междисциплинарным командам, работающим над творческими проектами в контексте учреждений высшего образования. В частности, в нем предлагается интегрировать дизайн-мышление и технологии, основанные на искусственном интеллекте, в образовательную методологию для улучшения коммуникации, вовлеченности, персонализированного обучения и интерактивности. Предполагаемые результаты такого подхода заключаются в решении одной из задач, стоящих перед учебными заведениями высшего образования, заключающейся в развитии у студентов творческих способностей, понимания процесса обучения, критического мышления и навыков решения проблем. Этот образовательный проект разрабатывается в сотрудничестве с кафедрой промышленного дизайна и учебным центром Сиань Цзяотун-Ливерпульского университета (XJTLU). Методология включает в себя обзор литературы по дизайн-мышлению, опросники по сбору данных от студентов школы дизайна в XJTLU, и эксперименты с помощниками по искусственному интеллекту. Интеграция динамических инструментов, таких как Articulate Rise 360 и искусственного интеллекта, позволила визуализировать концепции и создавать интерактивный контент для учащихся. В результате были представлены два прототипа образовательного проекта, которые привносят новую модель мышления в методологию дизайн-мышления и внедряют экспериментальные интерактивные технологические функции. Применяя этот подход, преподаватели могут создать среду, способствующую развитию навыков, необходимых в 21 веке.

Ключевые слова: Модель дизайн-мышления, навыки 21 века, компьютеризированное обучение, искусственный интеллект, интерактивность, креативность, персонализация

1. Introduction

In today's rapidly changing world, higher education (HE) institutions face numerous challenges that call for novel approaches to teaching, learning, and research. Some of the challenges include a need to keep up with technological innovations to enhance teaching and learning experiences, support online education, and improve administrative processes [Gamrat et al., 2021]; the importance to support students' engagement that was impacted by the pandemic and an increased tendency towards online education; and a need to foster the culture of research, critical thinking skills, and creativity in the HE institutions in general [Bezanilla et al., 2021], and Chinese STEM institutions in particular [Prashant et al, 2021]. Moreover, the 21st century presents a range of complex challenges that require novel skills and approaches. In their article "Changing Design Education for the 21st Century," Don Norman and Michael W. Meyer [2019] highlight the importance of human-centered design and

Design Thinking (DT), teamwork, management, and leadership to address performance, systemic, contextual, and global challenges.

To address these challenges, researchers and educators must explore innovative ways to foster student engagement and enhance critical thinking and creative behavior. Interdisciplinary collaboration is seen as a way to achieve innovation and creativity [Moirano, Sánchez & Štěpánek, 2020]. One potential approach to increase indterdisciplinary collaboration is to integrate Design Thinking and technology-enhanced learning into higher education curricula in the form of a practice-oriented online course on creative thinking open to learners from different educational backgrounds. By leveraging technology and DT, educators can create interactive, collaborative, and immersive learning experiences that promote critical thinking, creativity, and problem-solving skills.

Design Thinking, a methodology that supports creative confidence and creative behavior, and broadly promoted in the business environment [Kelley&Kelley, 2013], can address the challenges associated with the interdisciplinary collaboration, such as difficulties in communication rooted in differences in professional terminology. Design Thinking methodology has a range of supporting thinking tools using schemes, graphs, and other visual forms of communication, that facilitate the exchange of ideas between different stakeholders. In parallel, the integration of technology in education can improve student engagement and motivation [Kirschner & Karpinski, 2010]. However, it is important to note that technology should be used to support the learning objectives and not distract from them [Clark, 2012]. This study shares a strategy for promoting and facilitating interdisciplinary learning and communication. The strategy is to develop a technology-enhanced online course on Design Thinking aimed at fostering student engagement, promoting the interdisciplinary learning and creative culture in the university. The research question guiding this study was: How to communicate knowledge and facilitate idea

exchange among learners through Design Thinking and technology-enhanced learning? To answer this question, we conducted a comprehensive review of the literature on Design Thinking, collected students' feedback on the current practice of DT at the Design School of XJTLU, and developed a tester course using the Articulate Rise 360 and several Artificial Intelligence (AI) assistants to increase the interactivity of the course. The novelty of this project lays in rethinking the Design Thinking process based on the identified students' needs and in experimenting with the various interactive technological features, including the AI, to improve student engagement by personalizing the learning process and incorporating interactive elements. It proposes Design Thinking and visualization skills as a communication methodology for the interdisciplinary teams working on creative projects and as a strategy for the HE institutions to promote critical thinking, teamwork, management, and leadership among the learners. The next chapter will introduce more specifically the methodology and the achieved results.

2. Materials and methods

As mentioned in the introduction, the guiding research question of this project was: How to communicate knowledge and facilitate idea exchange among learners through Design Thinking and technology-enhanced learning? To achieve a better understanding on this topic, we aimed at developing an interactive course open to learners from different backgrounds that would introduce Design Thinking methodology as an iterative[1], step by step process supported by the interactive exercises and other features.

To achieve this goal, we have set the following research objectives:

[1] Iteration – the process of doing something again and again, usually to improve it, or one of the times you do it (Retreived from https://dictionary.cambridge.org/dictionary/english/iteration). Iteration is an important characteristic of the Design Thinking methodology.

RO1. To learn the principles and methods of Design Thinking;

RO2. To understand the students' perception of the current Design Thinking practices at the XJTLU Design school;

RO3. To develop interactive online experiences to stimulate students' engagement and create a supportive learning environment.

2.1 "Designerly way of thinking"

To reach the RO1., we have conducted the review of literature on Design Thinking. Design Thinking was popularized by IDEO in 1990s as a methodology to facilitate creativity in a multidisciplinary environment and stimulate creative confidence. David and Tom Kelley [2013] state that confidence is the factor that supports creative thought and helps turn ideas into reality. In Design Thinking, creative confidence is built thanks to the organized way of thinking and a set of rules that promote a supportive, creative environment. As building such an environment is one of our goals, we learn from the best practices of DT to implement in our course and find room for improvement.

DT typically contains five thinking steps: empathize, define, ideate, prototype, and test [Fig. 1].

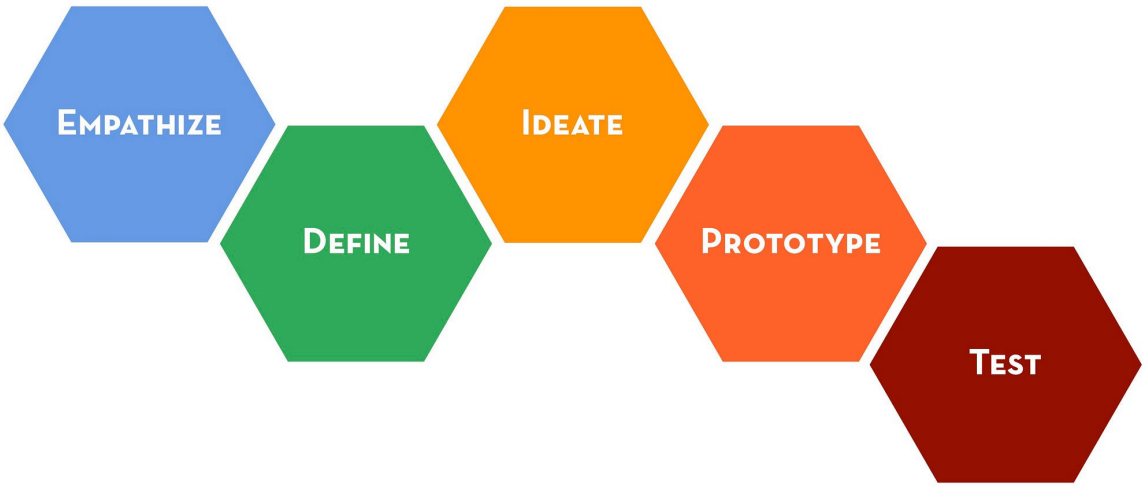

Figure 1. Design Thinking model developed by "d.School" at Stanford University. Модель дизайн-мышления, разработанная школой "d.School." при Стэнфордском университете.

In the article "The History of Design Thinking", Dam R.F. and Teo Y.S. mention several steps of the DT development. Starting from 1960s, when attempts were made to make design scientific and the term "wicked problems"[2] was invented, to 1970-80s when the principles of Design Thinking started to emerge and the solution-focused way of thinking was observed, which was in a way a pivoting point for the methodology. Bryan Lawson discovered a "designerly way of thinking" by conducting an experiment giving the same task to the students representing two different groups of disciplines – "scientists" and "designers". In particular, he realized that designers tend to focus on the solution, unlike the scientists, who focus on the problem. Designers' method of thinking was to generate a large number of solutions and eliminate those which did not work: "A central feature of design activity, then, is its reliance on generating fairly quickly a satisfactory solution, rather than on any prolonged analysis of the problem" [Dam & Teo, 2022]. Starting from 1990s, IDEO brought DT into the mainstream. The reason for its success was due to the customer-friendly terminology developed by IDEO which made the process more accessible to those not educated in design methodology. As a result, it quickly gained popularity in the business environment thanks to its universality that allows anyone seeking innovation to practice it [Dell'Era et al., 2020]. While the DT is mostly well-known thanks to the initiatives of IDEO and the Stanford "d.School", at present, we can find several other influential thinking models developed by other schools (Table 1).

[2] Wicked problems – a term coined by Horst Rittel to describe problems which are multidimensional and extremely complex [Dam & Teo, 2022].

Design Thinking Model	**Stages of innovation process**			
	Needs finding	Concept generation	Concept validation	Concept development
IDEO	Inspiration	Ideation	Ideation	-
d. School	Empathize and Define	Ideation	Prototype and Test	-
Darden School	What is	What if	What wows	What works
IBM	Observe	Reflect	Make	-
Continuum	Discover deep insights	Create	Make it real: prototype and test	Deploy
DMI	Understand and Observe	Conceptualize	Validate	Implement

Table 1. Comparative framework of models of Design Thinking process. Source: Silva et al., 2020. Сравнительная структура моделей процесса дизайн-мышления. Источник: Silva et al., 2020.

Despite differences in how the phases are named, the common idea behind is to organize the Design Thinking process into thinking stages that lead to innovation [Silva et al., 2020]. Each stage has some tools facilitating the process, helping the design team progress and achieve results. Examples include such tools as “Persona”, ‘Empathy Map”, “Harris profile” [Fig. 2], “User Journey”, and more. These tools visualize the thinking process, thus, facilitating the decision-making.

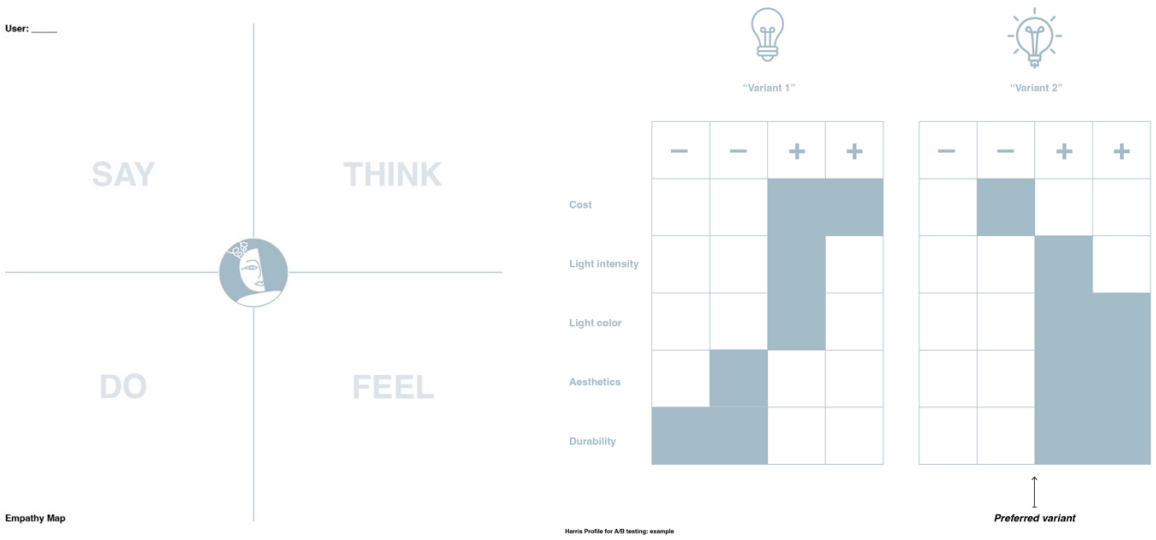

Figure 2. On the left: "Empathy Map", a tool that facilitates empathy towards the selected user group. On the right: "Harris profile", a tool that facilitates the comparison between the two ideas. Templates drawn by the author. Слева: "Карта эмпатии", инструмент, который облегчает сопереживание выбранной группе пользователей. Справа: "Профиль Харриса", инструмент, который облегчает сравнение двух идей. Шаблоны отрисованы автором.

Recently, several web platforms have evolved to explain and promote Design Thinking tools, for example, IDEO design kit[3], Service Design Tools[4], This is Service Design Doing[5], etc. These tools and DT in general are commonly referred to by design educators [Dell'Era et al., 2020; Micheli, 2019], and represent interest for our research that aims to apply this methodology to create an educational environment that supports creative behavior and facilitates interdiscilpinary communication.

To sum up, Design Thinking is a methodology that facilitates creative thinking and supports creative behavior, and is easily received by people from different professional backgrounds. It organizes the thinking process into several stages to help the team who works on a creative task achieve results. Each stage is supported

[3] designkit.org
[4] servicedesigntools.org
[5] Thisisservicedesigndoing.com

by facilitating tools that help organize findings in a structured and meaningful visual manner. While we want to rely on the important references of DT to provide high quality experience to our future learners, we also want to look into the opportunities for improvement, and therefore we have conducted a survey that collected data on the students' current perception of the DT methodology. The data collection and analysis, as well as the results will be presented in the next chapters.

2.2 Collecting data on students' perception of Design Thinking

In order to reach the Research Objective 2 and understand the students' perception of the current Design Thinking practices at the XJTLU Design School, the author conducted a survey. The survey preparation involved the following steps: writing the research plan, creating the list of questions, seeking approval from the University Ethics Committee, collecting data online, and data analysis.

The author had a hypothesis that students might depreciate the value of the Design Thinking tools due to a lack of confidence in understanding the meaning and purpose of such tools rooted in confusion in terminology that multiplied dramatically in recent years. The survey allowed us to test this hypothesis through multiple-choice questions where students could select from answers depicting different degrees of their knowledge and confidence in relation to each design stage. Also, the survey included open-ended questions where students needed to write down lists of design tools related to a specific design stage or task (e.g., needs finding or concept generation). Additional questions asked whether the students appreciate the value of such design methodologies in developing their projects in the university or future jobs. Ultimately, the expected result was to identify the phase/activity of a creative project where students feel most and less confident about what they should do, how, and why.

The invitations to participate were distributed throughout internal University channels (e.g., emails), and 49 students from the Departments of Industrial Design,

Architecture, Civil Engineering, and Urban Planning provided their responses. The participation was anonymous, and the collected data was stored online and on a private device under a password.

The survey included both quantitative and qualitative data. The qualitative data was analyzed using content analysis method. The quantitative data analysis visualized the occurrence of certain answers (e.g., degrees of confidence in relation to a project phase or activity). Open-ended questions aimed at exploring students' opinions that may fit and go beyond the hypothesis.

In the "Results" and "Discussion" chapters, the author will summarize and discuss the survey results. The results of the survey provided insights into the structure the online course content.

2.3 Instructional Design

To achieve the Research Objective 3 "To develop interactive online experiences to stimulate students' engagement and create a supportive learning environment", we followed specific instructional design that promotes active learning. Active learning refers to strategies that engage learners in the learning process. Instead of passively receiving information (e.g., listening), learners actively do things (e.g., writing, brainstorming, or interacting) and reflect on what they are doing; the process often involves higher order thinking (e.g., analysis, evaluation, and creation) and immediate instructor feedback for improvement, therefore fostering deeper learning and better learner motivation [Bonwell & Eison, 1991]. Applying what they have learned, reflecting on the process, and engaged in the learning process are the three fundamental elements of active learning [Skillshub, 2023]. The motivators for engagement to learners include whether the course content is interesting and relevant to them, whether they have the confidence to apply the knowledge and skills gained

in the real-world, and whether they are satisfied with the learning experience[6]. When designing and developing the course, we put active learning and learner engagement at the forefront, and the instructional design included the following components:

- Guiding questions;
- Real-world student cases;
- Assessment as Learning;
- Interactive e-learning module;
- AI-generated multimodal content.

Guiding questions

With guiding questions provided before each video lecture or student example, learners can focus on key points, challenge assumptions, and engage in deeper thinking rather than passively listening and watching the content. With knowledge check questions provided for important concepts, learners can test their understanding and receive immediate automated feedback. This is also a process of reinforcing learning and building confidence.

Real-world student cases

We invited students who have already practiced similar exercises in their "Design studio" classes to record a short video sharing the process, steps, and tools used for completing a certain task, and asked them to reflect on the process of completing the task by talking about problems encountered, lessons learned, experience gained, or suggestions for new learners. We used the cases as examples in the hands-on exercises. In this way, learners learn from others' experience, bringing theory to life and making learning more concrete and applicable.

Assessment as Learning

[6] arcsmodel.com

The purpose of assessment is not only for determining whether a learner has acquired the knowledge and skills but also about reinforcing learning and improvement. The exercises portion for each lesson is designed as both learning process and assessment. By following the step-by-step tutorials to complete the hands-on exercises, using the rubrics to self-assess their work, and submitting their final work for further personalized instructor feedback, learner can gradually develop skills in a formative way.

Interactive e-learning module

Technology plays an important role in facilitating self-directed learning. By using Articulate Rise 360, we created self-paced e-learning modules that allow learners to interact with the content, check their knowledge and get instant feedback, and engage in active learning for the most by thinking, applying, and reflecting.

AI generated multimodal content

We have been exploring solutions to communicating knowledge in a more engaging, effective and efficient way. We tried Generative AI tools, such as XIPU AI and D-iD platforms, to brainstorm ideas for quiz items and generate multimedia instructional materials such as instructional videos and audio for the course. In particular, for video-based knowledge communication, we used a piece of an original video-recording to create the AI-animated instructional short videos that allow us to produce and test the knowledge communication style and content quickly [Fig. 3]. Keeping up with the trend of integrating AI in higher education and make the learning process more interesting and intelligent, we go back to our goal of creative active and engaging learning experiences for our students. In the “Conclusions” chapter, we will discuss potential benefits and shortcomings, and future steps in developing the interactive and supportive online environment.

Figure 3. The image above shows a screenshot of the original analog video and the two screenshots from the videos generated with D-iD platform: one “neutral” and one “happy”. The depicted person has given her permission to publish this image in this article. На изображении выше показан скриншот оригинального аналогового видео и два скриншота из видео, сгенерированных с помощью платформы D-iD: “нейтральный” и “счастливый”. Изображенный человек дал свое разрешение на публикацию этих изображений в данной статье.

3. Results

3.1 Students’ responses

The number of students who responded was 49, all non-native English speakers: UG and PG students from the XJTLU Design School. As it was mentioned in the “Methodology” chapter, students had to relate the degree of confidence to the design stages. There were identical options they could choose as an answer for each design phase, starting from the most confident to the less confident option. Also, they had to list some design tools and methods they use in those stages. The hypothesis was that students might devalue the Design Thinking tools due to the lack of confidence in comprehending the purpose of such tools and, thus, in conducting creative activities. Nonetheless, the results show that students reported a high degree of confidence. The summary percentage of answers showing students’ confidence is:

- Secondary Research – 80% of the respondents reported that they know what to do in this design phase,
- Primary Research – 78%,
- Ideation – 72%,
- Testing – 70%.

However, when providing the lists of tools they use, students would often write "internet", "interview", "software", and other generic words that have no relevance with the Design Thinking. Yet, the reported variety of listed tools demonstrated that students indeed feel confident about it:

- 38 different design tools to be used during the Secondary Research,
- 20 tools for Primary Research,
- 35 for Ideation
- 9 for Testing.

We can note that students would approach the "Secondary research" and "Ideation" phases with a greater variety of design tools and methods, while "Testing" is only limited to 9 design tools.

The students were also asked to pick the design tools they knew and feel familiar about them. The list was built according to what the colleagues from XJTLU Department of Industrial Design would often use. The results show the following tools and methods reported as the most familiar to the students:

- Mind Map (85% of the respondents),
- Interview (81%),
- Brainstorm (81%).

Unexpectedly, many other popular tools, such as "Empathy Map", "Affinity Diagram" and "Analogous Inspiration" received little recognition (below 20%).

One of the expected results of this survey was to identify the design phase or activity where students feel most and less confident in terms of what they should do, how, and why. Students were provided a list of tasks to select from, and they reported the following design tasks as the most challenging:

- "Collecting data from users" (43% of the respondents),
- "Synthesizing the findings into a clear picture" (43%),
- "Coming up with interesting ideas" (49%),
- "Proceed from 'thinking' and 'discussing' to acting and developing the project" (43%),

Mentioning "I don't know how to start" and "lack of relevant examples" as reasons for their difficulties. Other design tasks listed in the survey received fewer points, including "research on the Internet", "finding books/articles", "identifying users/target audience", "explaining my findings to others", and "collaborating and communicating with peers". In the "Discussion" chapter, we will return to these results in a relation with the existing literature on Design Thinking.

3.2 Educational project

This project itself represents a "designerly way of thinking", in a way that it followed the five steps of Design Thinking: it 1). "empathized" to the users through the survey, 2). "defined" the problem through data analysis and literature review, 3). "ideated" based on the research findings and with the help of AI, and 4). "prototyped" a section of the online course to be 5). "tested". In this paragraph, we will describe the two "prototypes": a PDF manual titled "Creative Thinking tools reference guide for XJTLU UG design students and all interested" and the online course section "Mapping" developed on the platform Articulate Rise 360. The reference guide[7] [Fig.

[7] Zolotova, M. (2024). Creative Thinking tools reference guide for XJTLU UG design students and all interested. figshare. Preprint. https://doi.org/10.6084/m9.figshare.25602636.v4

4] was designed to support students from different educational backgrounds in the creative process. It is based on the principles of Design Thinking, synthesizing several of the most influential resources on Design Thinking and Service Design.

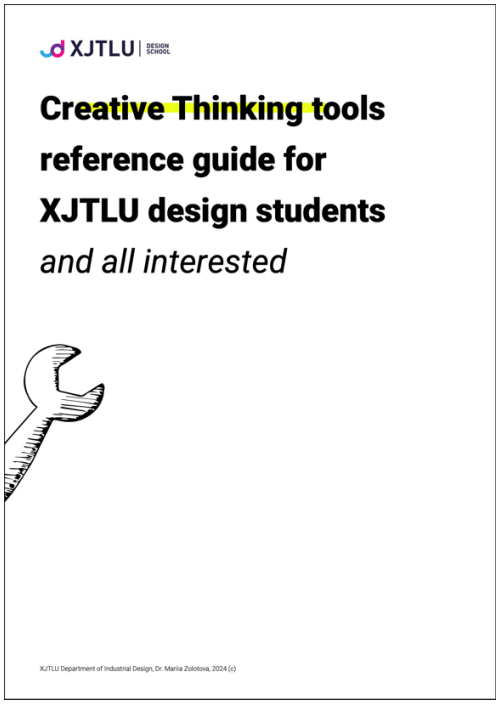

Figure 4. Zolotova, M. (2024). Creative Thinking tools reference guide for XJTLU UG design students and all interested, cover. [Золотова, М. (2024). Справочник по инструментам творческого мышления для студентов-дизайнеров XJTLU UG и всех заинтересованных], обложка. figshare. Preprint. https://doi.org/10.6084/m9.figshare.25602636.v4.

Additionally, it provides a short reference to presentation techniques. This guide recommends steps for developing creative projects, yet reminding the learners that creativity is a non-linear, iterative process that welcomes critical reflection and learning from errors. The guide splits the creative process into “Thinking & Structuring” and “Narrating & Representing”. This structure is not typical to the Design Thinking models and is a new thinking model [Fig. 5] aimed at providing additional assistance to the learners who may have never had experience in visualizing their research. It aims to highlight the importance of visual

communication and storytelling skills, which are typical to designers and efficient in a multidisciplinary environment characterized by challenges in communication. The part “Narrating& Representing” is designed to support the development of visualization skills through tips on the principles of visual deign, storytelling, and different formats and media. The parts respectively respond to the questions on how to organize the thinking process of a project and how to explain the project to peers, teachers, and other audiences. The idea behind creating this guide was to help students take a step from procrastinating to acting, which derives from the conducted survey. This guide was designed to encourage them to start learning by trial and error with the support of internationally recognized methods in design-related professions.

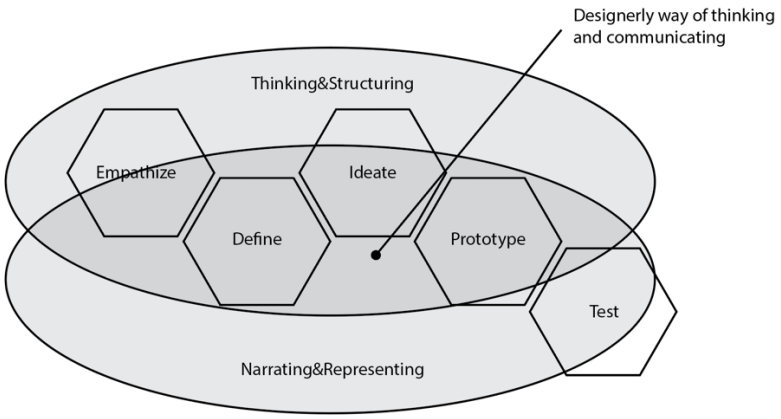

Figure 5. A new thinking model that represents a two-fold approach to Design Thinking emphasizing on the visual communication and the importance of storytelling. Source: author. Новая модель мышления, которая представляет собой двойной подход к дизайн-мышлению, подчеркивающий важность визуальной коммуникации и сторителлинга. Источник: автор.

The online environment mirrors the structure of the manual, and supports each step with guiding questions, examples from peers, interactive exercises such as drag-and-drop and multiple-choice questions, interactive features, such as flipping cards, and

multimedia contents (e.g., texts, videos by the tutor and by the students, videos generated by the AI, example images, templates for hands-on exercises). Currently, the visual features of this course cannot be fully shared in this paper because the course is not yet authorized to be accessed by the external users.

The manual and online course content was developed based on the literature review and the survey results. The survey demonstrated that “Mapping” was one of the most recognized and familiar tools associated with Design Thinking. Besides that, “Mapping” is a very visual way of communicating research and ideas (e.g., through mind maps, system maps, etc.)., which led us to a decision to make a tester based on “Mapping” exercises. Also, the survey demonstrated that students perceived some design tasks as challenging because “they didn’t know how to start” and “lacked relevant examples”. In the online environment, each “Mapping” exercise starts with an introductory video by the tutor, followed by the students’ examples where they highlight the background of their projects, explained their goals and motivations and the step-by-step process with the specific techniques and technologies they used. This was done to respond to the users’ needs mentioned above. After watching the videos, the learners should test their knowledge through interactive exercises. These adaptive, computer-graded exercises can provide immediate feedback and personalized guidance to students as they work through the material. Then, the learners are briefed with three to five simple steps to complete, each step is designed to be easy to understand and with tips on techniques and technologies needed to accomplish it, and supported by the visual interactive features (e.g., flipping cards [Fig. 6], templates [Fig. 7], example images). Once the exercise is complete, learners are invited to self-assess their work with the given criteria. Thus, the course provides intelligent evaluation and feedback to help students improve their work, rather than relying solely on an instructor's assessment. It also corresponds with the value of Design Thinking which implies the iterative process as key to finding successful

solutions. Each step can be repeated, rewatched, edited by the learners until they feel satisfied. All in all, the idea was to provide to the learners support so that they can navigate and practice the new knowledge independently without the fear of making irreversible mistakes.

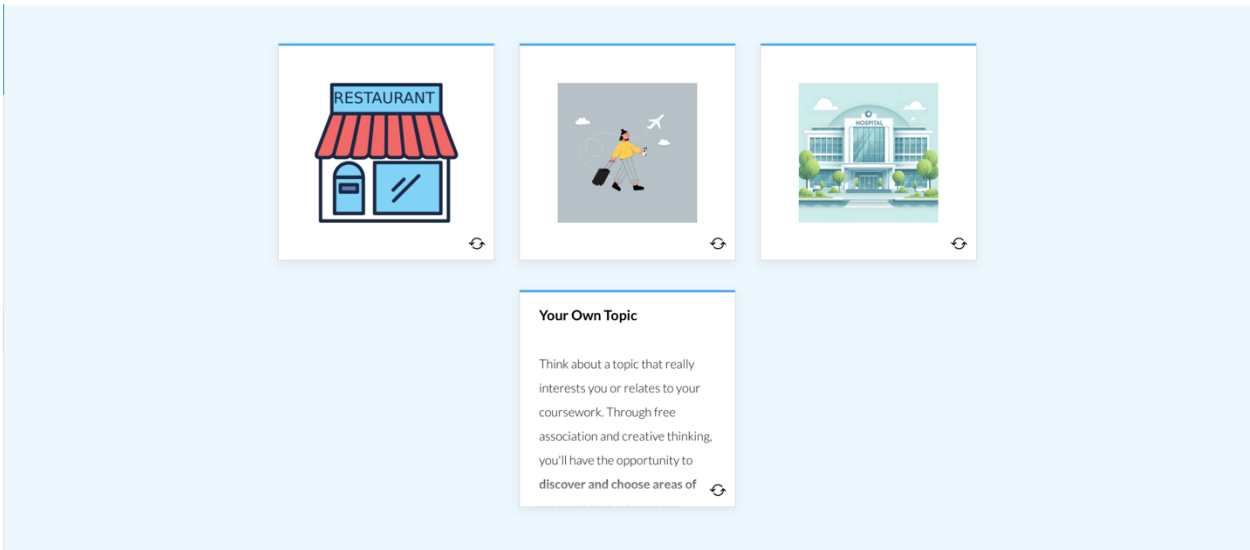

Figure 6. A screenshot from the online-course, interactive flipping cards. Скриншот из онлайн-курса, интерактивные переворачиваемые карточки.

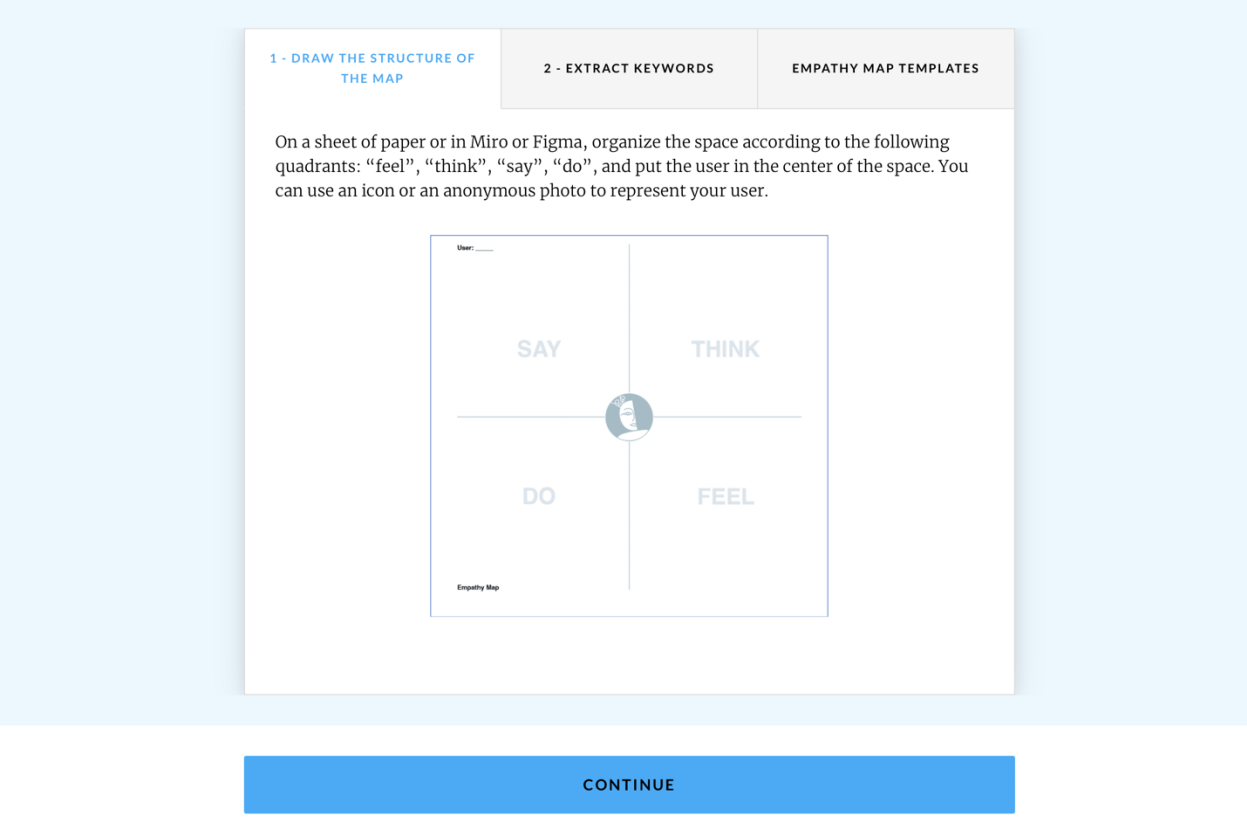

Figure 7. A screenshot from the online-course, a template for the students’ independent homework. Скриншот из онлайн-курса, шаблон для самостоятельной работы студентов.

This project followed the Design Thinking methodology to develop interactive online experiences to stimulate students’ engagement and create a supportive learning environment for intellectual creative activities. As an intermediate result, it achieved an understanding of the principles and methods of Design Thinking; students’ perception of the current Design Thinking practices at the XJTLU Design School; and developed a section of the future online course which content and interactive features reflect the research findings. Following the Design Thinking methodology, the next step will be to test the “Mapping” section and find ways to provide more support to the learners thanks to the AI-driven interactive features. Specific future steps will be discussed in the chapter “Conclusions”.

4. Discussion

Fostering student engagement and enhancing critical thinking and creative behavior in higher education is a critical goal for educators. Interdisciplinary collaboration can help achieving this goal, yet it is characterized by the difficulties in communication. One approach that has shown promise in achieving this goal is Design Thinking, a problem-solving methodology that uses simple language and visual forms of communication, and emphasizes empathy, ideation, prototyping, and testing [Brown, 2009]. Design thinking has been found to increase student engagement and motivation [Lin & Eichelberger, 2020] and to promote critical thinking and creative problem-solving skills [Lidwell, 2010]. Technology-enhanced learning is another approach that can enhance student engagement and learning outcomes. By integrating technology-enhanced learning with Design Thinking, educators can create interactive, collaborative, and immersive learning experiences that promote critical thinking, creativity, and problem-solving skills. Design Thinking has been known for building creative confidence in learners which is considered one of the factors that supports creative behavior [Kelley & Kelley, 2013]. Beghetto, Karwowski, and Reiter-Palmon's [2021] work studies the relationship between creative confidence and creative behavior, and they argue that creative confidence does not always lead to creative behavior, but it is the willingness to take intellectual risks that enhances the link between the two. The survey results also partially support this statement, as 70-80% of the respondents reported high degree of confidence in each design phase, yet "coming up with the interesting ideas" and "proceed from thinking and discussing to acting and developing the project" were reported as most challenging tasks. Thus, these results demonstrate the break between the perceived confidence and creative behavior.

Taneri and Dogan [2021] link frustration with learning how to work on creative projects with the focus of design studio classes on designing products (final

outcomes) rather than learning design steps or processes. The conducted survey also supports this statement, as majority of the respondents reported that the mentioned above design phases are challenging because they don't know how to begin with the task. The open-ended nature of design can make its learning confusing and frustrating, which can reduce their motivation and willingness to engage [Kavousi et al., 2019]. Also, Kavousi et al. argue that metacognition can help students overcome this problem, especially in the ideation phase.

Another approach to enhancing students' engagement and facilitate knowledge and ideas' communication is to introduce interactive technologies and exercises into the course design. Research has shown that allowing students to prototype and iterate on creative ideas can significantly boost engagement and motivation [Resnick & Rosenbaum, 2013]. By blending instructional content with these exploratory, creative spaces, the technology-enhanced learning experience can become more immersive and stimulating for students. Another important consideration is the integration of social and collaborative elements. Peer-to-peer interaction and feedback in creative learning environments is important. Incorporating features like discussion forums and virtual studios can stimulate exchange of ideas, critique, and mutual learning. However, personal educational practice often demonstrate that peer learning is stronger in the offline scenarios. AI-driven systems can help students experience the creative process more effectively. Intelligent tutoring and adaptive learning technologies can assist with monitoring student progress, identifying knowledge gaps, and providing real-time, contextualized guidance, thus, enhancing the personalization and responsiveness of the creative learning experience [Sottilare et al., 2018]. Furthermore, the integration of multimedia, such as video tutorials, interactive visualizations, and creative examples, can make the learning content more engaging and accessible. By implementing these features, the technology-enhanced learning experience can become a more dynamic, interactive, and

responsive platform that empowers students to actively engage in creative processes, explore their ideas, and collaborate with their peers, ultimately fostering a deeper, more meaningful learning experience.

5. Conclusion

This project represents a strong "designerly way of thinking" by following the five key steps of Design Thinking. It answers the research question “How to communicate knowledge and facilitate idea exchange among learners through Design Thinking and technology-enhanced learning?” with the two deliverables: a comprehensive "Creative Thinking tools reference guide" and a prototype section of an interactive online course focused on the "Mapping" design technique. The reference guide was developed to support students from diverse backgrounds in the creative process, covering both the thinking/structuring and narrating/representing aspects. Introducing the two-phased thinking model to the course is a methodological novelty to the Design Thinking models aimed to support learners from non-design backgrounds to assist them develop visualizing skills necessary in the multidisciplinary communication. The guide synthesizes influential Design Thinking and Service Design methods to encourage students to actively engage in learning through trial-and-error. Similarly, the online course prototype mirrors the structure of the manual, providing students with step-by-step guidance, examples, interactive exercises, and self-assessment opportunities around the "Mapping" technique as a tester-section of the course. This aligns with the survey findings that students struggle to start design projects and lack relevant examples. Eventually, we concluded with the three strategies to communicate knowledge and facilitate idea exchange among learners with different professional backgrounds:

- To split knowledge communication into small step-by-step instructions;

- To emphasize the visual tools of knowledge delivery and research communication;
- To implement multimodal knowledge communication to achieve a better comprehension and engagemnt;
- To use the AI-driven instructional videos to produce and test the knowledge communication style and content quickly.

Overall, this project demonstrates a user-centric approach to developing supportive resources for cultivating creative thinking and design skills in an interactive, iterative manner. The next step will be to further test and refine the online course prototype based on the students' feedback, and leverage AI-driven features to provide a more up-to-date support and guidance to the learners. For instance, we plan to experiment and create an AI-tutor trained with the materials of the course to help students answer their questions or even provide constructive feedback on their work at any moment of time. However, the use of AI assistant to generate a human-mimicking tutor would raise the following research questions that need further exploration:

- Currently, the AI-driven image doesn't look natural, shall we seek a more natural look or create a clearly "robotized" or "artistic" image to provide transparancy to the learners in terms of origin of the knowledge? In other words, this question addresses the ethic of the AI.
- What are the different values that a digital and real tutor can provide to the learners?
- Will the use of AI-tutor affect engagement positively or negatively?

All in all, the project represents a good platform for methodological and technological experiment in Higher Education that fosters interdisciplinary collaobration, crticial thinking skills and student engagement through creativity, interactivity, and supportive learning environment.

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