full article
https://elibrary.ru/nderzg

Communication Strategies for Interdisciplinary Teams Through Design Thinking and Technology-Driven Personalized Learning in Higher Education

Mariia L. Zolotova
Xi'an Jiaotong-Liverpool University, China, Suzhou
St. Petersburg University, Russia, St. Petersburg
https://orcid.org/0000-0003-0085-3225
Mariia.Zolotova@xjtlu.edu.cn
Xinrong Xue
Xi'an Jiaotong-Liverpool University, China, Suzhou
https://orcid.org/0009-0000-8914-3232

Abstract: The paper discusses how Design Thinking and Technology-Enhanced Learning can support multidisciplinary teams in Higher Education 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 of students. The results of this approach are to address the challenges of Higher Education consisting in students' assessment of the learning process, developing their creativity, critical thinking, and problem-solving skills. This educational project is designed in collaboration with the Department of Industrial Design and the Learning Mall at Xi'an Jiaotong-Liverpool University. The methodology includes a literature review on Design Thinking and analysis of surveys from the Design School students at Xi'an Jiaotong-Liverpool University and the AI assistants. Dynamic tools such as Articulate Rise 360 and AI have made it possible to visualize concepts and create interactive content for learners. The results include two educational prototypes that introduce a new thinking model to Design Thinking methodology and share experiments with interactive technological features. Applying this approach, teachers can create an environment conducive to the development of skills needed in the 21st century.

Keywords: Design Thinking model, 21st century skills, Technology-Enhanced Learning, AI, interactivity, creativity, personalization

Citation: Zolotova M. L., Xue Xinrong. Communication Strategies for Interdisciplinary Teams Through Design Thinking and Technology-Driven Personalized Learning in Higher Education. *Virtual Communication and Social Networks*, 2024, 3(3): 191–202. https://doi.org/10.21603/2782-4799-2024-3-3-191-202

Received 3 Jun 2024. Accepted after review 14 Aug 2024. Accepted for publication 19 Aug 2024.

оригинальная статья

Коммуникационные стратегии для междисциплинарных команд с использованием дизайн-мышления и персонализированного обучения на основе компьютерных технологий в высших учебных заведениях

Золотова Мария Леонидовна
Сиань Цзяотун-Ливерпульский университет, Китай, Сучжоу
Санкт-Петербургский государственный университет, Россия, Санкт-Петербург
https://orcid.org/0000-0003-0085-3225
Mariia.Zolotova@xjtlu.edu.cn
Сюэ Синронг
Сиань Цзяотун-Ливерпульский университет, Китай, Сучжоу
https://orcid.org/0009-0000-8914-3232

Аннотация: Проанализировано, как дизайн-мышление и обучение, основанное на компьютерных технологиях, могут помочь междисциплинарным командам, работающим над творческими проектами в учреждениях высшего образования. Предложено интегрировать дизайн-мышление и технологии, основанные на искусственном интеллекте, в образовательную методологию для улучшения коммуникации, вовлеченности, персонализированного обучения и интерактивности студентов. Результаты исследования решают одну из задач учебных заведений высшего образования, заключающуюся в понимании учащимися процесса обучения и развитии у них творческих способностей, критического мышления, навыков решения проблем. Образовательный проект разработан в сотрудничестве с кафедрой промышленного дизайна и учебным центром Сиань Цзяотун-Ливерпульского университета. Методология включает: обзор литературы по дизайн-мышлению, опросники по сбору данных от студентов школы дизайна в Сиань Цзяотун-Ливерпульском университете и эксперименты с помощниками по искусственному интеллекту. Интеграция динамических инструментов, таких как *Articulate Rise 360* и искусственного интеллекта, позволила визуализировать концепции и сформировать интерактивный контент для студентов. Представлены два прототипа образовательного проекта, которые привносят новую модель мышления в методологию дизайн-мышления и внедряют экспериментальные интерактивные технологические функции. Этот подход позволяет преподавателям создать среду, способствующую развитию навыков учащихся, необходимых в XXI в.
Ключевые слова: модель дизайн-мышления, навыки XXI века, компьютеризированное обучение, искусственный интеллект, интерактивность, креативность, персонализация

Цитирование: Золотова М. Л., Сюэ Синронг. Коммуникационные стратегии для междисциплинарных команд с использованием дизайн-мышления и персонализированного обучения на основе компьютерных технологий в высших учебных заведениях. *Виртуальная коммуникация и социальные сети.* 2024. Т. 3. № 3. С. 191–202. (In Eng.) https://doi.org/10.21603/2782-4799-2024-3-3-191-202

Поступила в редакцию 03.06.2024. Принята после рецензирования 14.08.2024. Принята в печать 19.08.2024.

Introduction

In today's rapidly changing world, Higher Education 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 [Glantz et al. 2021]. Other challenges are the importance of supporting student engagement, which has been affected by the pandemic and an increased trend toward online education, as well as the need to promote the culture of research, critical thinking skills, and creativity in Higher Education in general [Bezanilla et al. 2021], and Chinese STEM institutions in particular [Loyalka et al. 2021]. Moreover, the 21st century presents a range of complex challenges that require

novel skills and approaches [Cai, Yan 2019]. Authors highlight the importance of human-centered design [Varanasi et al. 2020] and Design Thinking, teamwork, management, and leadership to address performance, systemic, contextual, and global challenges [Meyer, Norman 2020].

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

Design Thinking is a methodology that supports creative confidence and creative behavior, and is widely promoted in business environment [Kelley, Kelley 2013]. It can address the challenges associated with the interdisciplinary collaboration, such as communication difficulties due to differences in professional terminology. The Design Thinking methodology has a range of supporting thinking tools that use schemes, graphs, and other visual forms of communication to facilitate the exchange of ideas among different stakeholders. At the same time, integrating technology into education can improve student engagement and motivation [Kirschner, Karpinski 2010]. However, it is important to note that technology should be used to support learning objectives, not distract from them [Clark 2012]. This study presents a strategy for promoting and facilitating interdisciplinary learning and communication. The strategy is to develop a technology-enhanced online course on Design Thinking that will increase student engagement and foster interdisciplinary learning and a creative culture at the university. The research question that guided this study was: How can Design Thinking and Technology-Enhanced Learning be used to communicate knowledge and facilitate the exchange of ideas among learners? To answer this question, we conducted a comprehensive review of the literature on Design Thinking, collected students' feedback on the current practice of Design Thinking at Xi'an Jiaotong-Liverpool University (XJTLU) Design School, and developed a tester course using the Articulate Rise 360 and several AI assistants to increase the interactivity of the course. The novelty of this project lies in rethinking the Design Thinking process based on the identified student needs and experimenting with different interactive technology features, including 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 interdisciplinary teams working on creative projects, and as a strategy for Higher Education institutions to promote critical thinking, teamwork, management, and leadership among learners. More specifically, the methodology and the results obtained are presented below.

Methods and materials

As mentioned in the introduction, the guiding research question of this project was: How can Design Thinking and Technology-Enhanced Learning be used to communicate knowledge and facilitate the exchange of ideas among learners? For a better understanding of this topic, we aimed at developing an interactive course, open to learners from different backgrounds, that would introduce the Design Thinking methodology as an iterative, step-by-step process, supported by the interactive exercises and other features. Our research objectives are as follows:

1. Understand the principles and methods of Design Thinking.

2. Understand students' perceptions of current Design Thinking practices at XJTLU Design School.

3. Develop interactive online experiences to stimulate student engagement and create a supportive learning environment.

Designerly way of thinking

To achieve Research Objective 1, we conducted a literature review on Design Thinking. It was popularized by IDEO in the 1990s as a methodology to facilitate creativity in a multidisciplinary environment and to stimulate creative confidence. D. Kelley and T. Kelley state that confidence is the factor that supports creative thinking and helps turn ideas into reality [Kelley, Kelley 2013]. In Design Thinking, creative confidence is built through an organized way of thinking and a set of rules that promote a supportive, creative environment. Since creating such an environment is one of our goals, we learn from the best practices of Design Thinking to implement

in our course and find room for improvement. Design Thinking typically contains five thinking steps: empathize, define, ideate, prototype, and test (fig. 1).

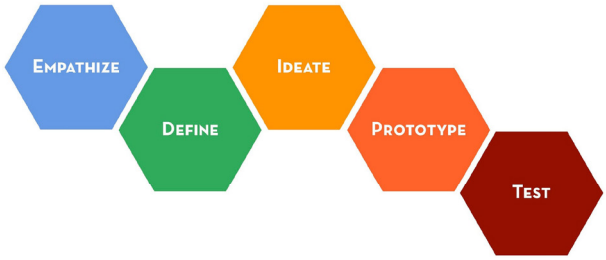

Fig. 1. Design Thinking model developed by *d.School* at Stanford University
Рис. 1. Модель дизайн-мышления, разработанная школой *d.School* при Стэнфордском университете

In the article "The History of Design Thinking", R. F. Dam and Y. S. Teo mention several steps in the development of Design Thinking. Starting from the 1960s, when attempts were made to make design scientific and the term *wicked problems*[1] was invented, to the 1970–80s, when the principles of Design Thinking began to emerge and the solution-focused way of thinking was observed, which was in a way a pivoting point for the methodology [Dam, Teo 2022]. B. Lawson discovered a "designerly way of thinking" by conducting an experiment in which students representing two different groups of disciplines – scientists and designers – were given the same task. Specifically, he found that designers tend to focus on the solution, as opposed to the scientists, who focused on the problem. The designers' way of thinking was to generate a large number of solutions and eliminate those that 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 in the 1990s, IDEO brought Design Thinking into the mainstream. The reason for its success was the customer-friendly terminology developed by IDEO, which made the process more accessible to those not trained in design methodology. As a result, it quickly gained popularity in business environment due to its universality, which allows anyone seeking to innovate to practice it [Dell'Era et al. 2020]. While the Design Thinking is best known thanks to the initiatives of IDEO and the Stanford *d.School*, we can currently find several other influential thinking models developed by other schools (tab.[2]).

Despite differences in how the phases are named, the common idea behind them 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 and help the design team progress and achieve results. Examples include tools such as *Persona*, *Empathy Map*[3], *Harris profile*[4] (fig. 2), User Journey, and more. These tools visualize the thought process and facilitate decision-making.

Recently, several web platforms have evolved to explain and promote Design Thinking tools, such as the IDEO design kit[5], Service Design Tools[6], This is Service Design Doing[7], etc. These tools,

Tab. Comparative framework of models for Design Thinking
Таб. Сравнительная структура моделей процесса дизайн-мышления

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

[1] "Wicked problems" a term coined by H. Rittel to describe problems which are multidimensional and extremely complex.
[2] Compiled by: [Silva et al. 2020].
[3] A tool that facilitates empathy towards the selected user group. Инструмент, который облегчает сопереживание выбранной группе пользователей.
[4] A tool that facilitates the comparison between the two ideas. Инструмент, который облегчает сравнение двух идей.
[5] DESIGNKIT. URL: https://www.designkit.org/ (accessed 7 May 2024).
[6] sdt. URL: https://servicedesigntools.org/ (accessed 7 May 2024).
[7] This is Service Design Doing. URL: https://www.thisisservicedesigndoing.com/ (accessed 7 May 2024).

 https://doi.org/10.21603/2782-4799-2024-3-3-191-202

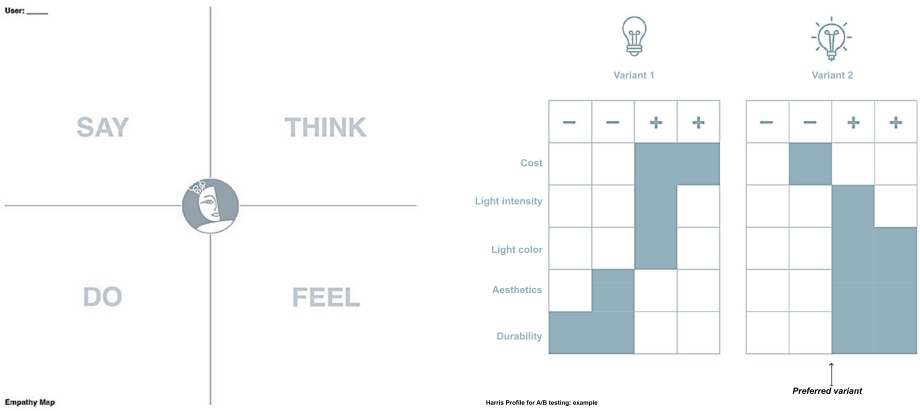

Fig. 2. Empathy Map (left), Harris profile (right)
Рис. 2. Карта эмпатии (слева), Профиль Харриса (справа)

and Design Thinking in general, are commonly referred to by design educators [Dell'Era et al. 2020; Micheli et al. 2019; Powers 2016] and represent interest for our research, which aims to apply this methodology to create an educational environment that supports creative behavior and facilitates interdisciplinary communication.

To sum up, Design Thinking is a methodology that facilitates creative thinking and supports creative behavior, and is easily adopted by people from different professional backgrounds. It organizes the thinking process into stages to help the team working on a creative task achieve results. Each stage is supported by facilitation tools that help organize findings in a structured and meaningful visual manner. While we want to rely on the important references of Design Thinking to provide a high quality experience for our future learners, we also want to look into the opportunities for improvement, and therefore we conducted a survey that collected data on the students' current perception of the Design Thinking methodology. The data collection, analysis, and the results will be presented next.

Collecting data on students' perception of Design Thinking

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

The authors hypothesized that students might discount the value of Design Thinking tools due to a lack of confidence in understanding the meaning and purpose of such tools, rooted in the increasing confusion of terminology in recent years. The survey allowed us to test this hypothesis through multiple-choice questions where students could choose from answers that represented different levels of knowledge and confidence in relation to each design stage. The survey also included open-ended questions that asked students to write down lists of design tools associated with a specific design stage or task (e.g., needs assessment or concept generation). Additional questions asked whether the students appreciated the value of such design methodologies in developing their projects at the university or in future jobs. Ultimately, the expected result was to identify the phase / activity of a creative project where students feel most and least confident about what they should do, how, and why.

The invitations to participate were distributed through internal University channels (e.g., emails), and 49 students from the Departments of Industrial Design, Architecture, Civil Engineering, and Urban Planning responded. Participation was anonymous, and the data collected was stored online and on a private device under a password.

The study included both quantitative and qualitative data. The qualitative data was analyzed using content analysis. The quantitative data analysis visualized the occurrence of certain responses (e.g., levels 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.

The authors will summarize and discuss the results of the survey in the Results and Discussion sections of the article. The results of the survey provided insight into the structure of the online course content.

Instructional Design

To achieve Research Objective 3, "To develop interactive online experiences that stimulate student engagement

and create a supportive learning environment," we followed a specific instructional design that promotes active learning. Active learning refers to strategies that engage learners in the learning process. Rather than 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., analyzing, evaluating, and creating) and immediate feedback from the instructor for improvement, thereby fostering deeper learning and better learner motivation [Bonwell, Eison 1991]. Applying what is learned, reflecting on the process, and engaging in the learning process are the three fundamental elements of active learning[8]. Motivators for learner engagement 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. We designed and developed the course with an emphasis on active learning and learner engagement, and the instructional design included the following components:

1. **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 content. Knowledge check questions for key concepts allow learners to test their understanding and receive immediate, automated feedback. This also reinforces learning and builds confidence.

2. **Real student cases.** We invited students who had already done similar exercises in their "Design studio" classes to record a short video showing the process, steps, and tools used to complete a particular task, and asked them to reflect on the task completion discussing the 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, students learn from each other's experience, bringing theory to life and making learning more concrete and applicable.

3. **Assessment as Learning**. The purpose of assessment is not only to determine whether a learner has acquired the knowledge and skills, but also to reinforce learning and improvement. The exercises portion for each lesson is designed to be both a learning process and an 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 feedback from the instructor, the learner can gradually develop skills in a formative way.

4. **Interactive e-learning module**. Technology plays an important role in facilitating self-directed learning. Using Articulate Rise 360, we created self-paced e-learning modules that allow learners to interact with the content, test their knowledge, receive immediate feedback, and engage in active learning by thinking, applying, and reflecting.

5. **AI-generated multimodal content**. We explored solutions to deliver 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 part of an original video-recording to create the AI-animated instructional short videos, which allows us to quickly produce and test the knowledge communication style and content (fig. 3[9]). Following the trend of integrating AI into Higher Education and making the learning process more interesting and intelligent, we go back to our goal of providing creative, active, and engaging learning experiences for our students. In the Conclusions section, we will discuss potential benefits, shortcomings, and future steps in developing the interactive and supportive online environment.

Results

Students' responses

The number of students who responded was 49, all non-native English speakers: UG and PG students from XJTLU Design School. As mentioned in the Methodology section, the students had to relate the level 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 least confident option. They also had to list some design tools and methods they use in these stages. The hypothesis was that students might devalue the Design Thinking tools due to a lack of confidence in understanding the purpose of such tools and thus in carrying out creative activities.

[8] 15 active learning strategies and examples. *Skillshub*. 04.10.2023. URL: https://www.skillshub.com/blog/active-learning-strategies-examples/ (accessed 30 May 2024).

[9] The person depicted has given her permission to publish these images in this article. Человек дал свое разрешение на публикацию этих изображений в данной статье.

 https://doi.org/10.21603/2782-4799-2024-3-3-191-202

Fig. 3. The images from the videos generated with D-iD platform
Рис. 3. Изображения, сгенерированные с помощью платформы D-iD

However, the results show that students reported a high level of confidence. The summary percentage of answers showing student confidence is:

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

However, when providing lists of the tools they use, students often wrote *internet*, *interview*, *software*, and other generic words that have no relevance to the Design Thinking. However, the reported variety of tools listed demonstrated that the students were indeed confident about it:

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

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

The students were also asked to choose the design tools they knew and felt familiar with. The list was made according to what the colleagues from XJTLU Department of Industrial Design would often use. The results show that the following tools and methods were reported to be 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 outcomes of this survey was to identify the design phase or activity where students felt most and least confident about what to do, how, and why. Students were given a list of tasks to choose from, and they reported the following design tasks as the most challenging:

- Collecting data from users – 43% of the respondents.
- Synthesizing the results into a clear picture – 43%.
- Generating interesting ideas – 49%.
- Moving from thinking and discussing to taking action and developing the project – 43%.

I don't know how to start and *Lack of relevant examples* were cited as reasons for difficulties. Other design tasks listed in the survey received lower scores, including *researching on the Internet*, *finding books / articles*, *identifying users / target audience*, *explaining my findings to others*, and *collaborating and communicating with peers*. In the Discussion section, we will return to these results in relation to the existing literature on Design Thinking.

Educational project

This project itself represents a "designerly way of thinking" in that it followed the five steps of Design Thinking:

1) it *empathized* with the users through the survey,
2) it *defined* the problem through data analysis and literature review,
3) it *ideated* based on the research and with the help of AI, and
4) it *prototyped* a section of the online course,
5) to be *tested*.

In this section, we will describe the two "prototypes": a PDF manual entitled "Creative Thinking tools reference guide for XJTLU UG design students and all interested" and the online course section Mapping developed on the Articulate Rise 360 platform. The reference guide (fig. 4) is designed to support students from different educational backgrounds in the creative process. It is based on the principles of Design Thinking and synthesizes some of the most influential resources on Design Thinking and Service Design.

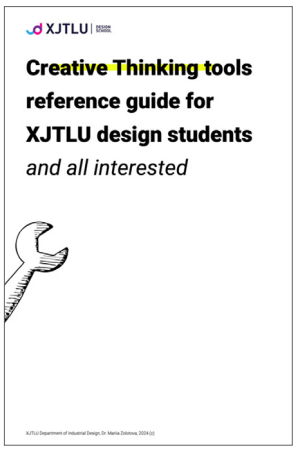

Fig. 4. The reference guide [Zolotova 2024]
Рис. 4. Справочное руководство [Zolotova 2024]

It also provides a brief reference on presentation techniques. This guide recommends steps for developing creative projects, while reminding learners that creativity is a non-linear, iterative process that welcomes critical reflection and learning from mistakes. The guide divides the creative process into Thinking & Structuring and Narrating & Representing. This structure is not typical of Design Thinking models and is a new model[10] (fig. 5) designed to provide additional support for learners who may not have had experience in visualizing their research. It aims to emphasize the importance of visual communication and storytelling skills, which are typical to designers and effective in a multidisciplinary environment characterized by communication challenges. The Narrating & Representing section is designed to support the development of visualization skills through tips on the principles of visual design, storytelling, and different formats and media. The sections respectively address 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 procrastination to action, which is derived from the survey conducted. This guide should encourage them to start learning by trial and error with the support of internationally recognized methods in design-related professions.

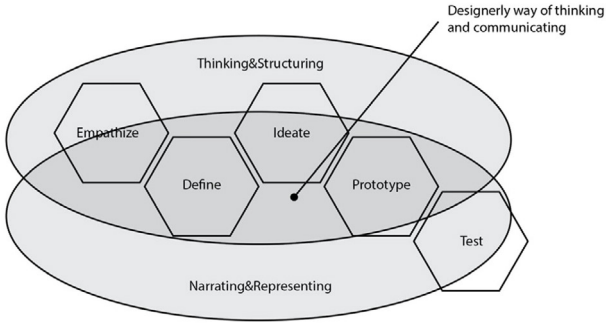

Fig. 5. A new thinking model
Рис. 5. Новая модель мышления

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, tutor and student videos, AI-generated videos, 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 for access by external users.

The manual and online course content were developed based on the literature review and the survey results. The survey showed that Mapping is one of the most recognized and familiar tools associated with Design Thinking. In addition, Mapping is a very visual way of communicating research and ideas (e.g., through mind maps, system maps, etc.), which led to the decision to create a tester based on Mapping exercises. The survey also showed that students found some design tasks challenging because *they didn't know how to start* and *lacked relevant examples*. In the online environment, each Mapping exercise begins with an introductory video by the tutor, followed by the students' examples, where they highlight the background of their projects, explain their goals, motivations, and the step-by-step process with the specific techniques and technologies they used. This was done to address the user needs mentioned above. After watching the videos, 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. Learners are then given three to five simple steps to complete, each step is designed to be easy to understand, provided with tips on the techniques and technologies needed to complete it, and supported by the visual interactive features (e.g., flipping cards (fig. 6), templates (fig. 7), sample images). At the end of the exercise, learners are invited to self-evaluate their work according to the given criteria. In this way, the course provides intelligent assessment and feedback

[10] It represents a two-fold approach to Design Thinking with an emphasis on the visual communication and the importance of storytelling. Она представляет собой двойной подход к дизайн-мышлению, подчеркивающий важность визуальной коммуникации и сторителлинга.

to help students improve their work, rather than relying solely on an instructor's assessment. It also aligns with the value of Design Thinking which implies the iterative process as key to finding successful solutions. Each step can be repeated, revisited, and edited by students until they feel satisfied. All in all, the idea was to support learners support in navigating and practicing the new knowledge on their own, without the fear of making irreversible mistakes.

This project followed the Design Thinking methodology to develop interactive online experiences to stimulate student 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 XJTLU Design School, and developed a section of the future online course whose 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 learners thanks to the AI-driven interactive features. Specific future steps will be discussed in the Conclusions section.

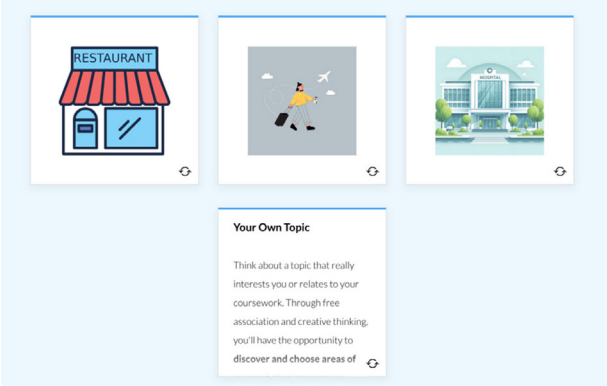

Fig. 6. A screenshot of the online-course, interactive flipping cards
Рис. 6. Скриншот онлайн-курса с интерактивными переворачиваемыми карточками

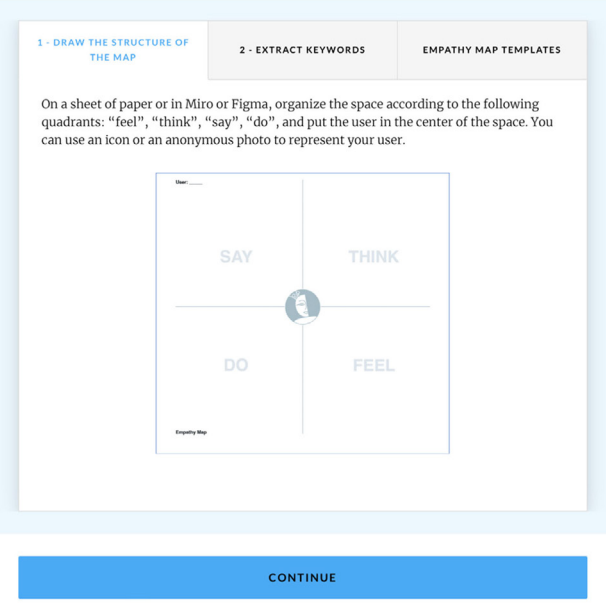

Fig. 7. A screenshot of the online-course, a template for the students' independent homework
Рис. 7. Скриншот онлайн-курса с шаблоном для самостоятельной работы студентов

Discussion

Fostering student engagement and improving 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 was shown to increase student engagement and motivation [Lin, Eichelberger 2020] and to foster critical thinking and creative problem-solving skills [Lidwell et al. 2010]. Technology-Enhanced Learning is another approach that can improve student engagement and learning outcomes. By integrating Technology-Enhanced Learning with Design Thinking, educators can create interactive, collaborative, and immersive learning experiences that foster critical thinking, creativity, and problem-solving skills. Design Thinking is known to build creative confidence in learners, which is considered one of the factors that supports creative behavior [Kelley, Kelley 2013]. The work of [Beghetto et al. 2021] explores 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 strengthens the link between the two. The survey results also partially support this statement, as 70–80% of respondents reported high levels of confidence in each design phase, but "generating interesting ideas" and "moving from "thinking" and "discussing" to taking action and developing the project" were reported as the most challenging tasks. Thus, these results demonstrate the disconnect between perceived confidence and creative behavior.

B. Taneri, F. Dogan link the frustration of learning how to work on creative projects to the focus of design studio classes on designing products (end results) rather than learning design steps or processes [Taneri, Dogan 2021]. The survey conducted also supports this statement, as the majority of respondents reported that the aforementioned design phases are challenging because they don't know how to start the task. The open-ended nature of design can make their learning confusing and frustrating, which can reduce their motivation and willingness to engage. Also argue that metacognition can help students overcome this problem, especially in the ideation phase [Kavousi et al. 2020].

Another approach to increase student engagement and facilitate the transfer of knowledge and ideas is to incorporate interactive technologies and exercises into the course design. Research has shown that allowing students to prototype and iterate creative ideas can significantly increase 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 are important in creative learning environments. Including features such as discussion forums and virtual studios can encourage the exchange of ideas, critique, and peer learning. However, personal educational practice often shows that peer learning is stronger in offline scenarios. AI-driven systems can help students experience the creative process more effectively. Intelligent tutoring and adaptive learning technologies can help monitor student progress, identify knowledge gaps, and provide contextualized guidance in real time, thereby enhancing the personalization and responsiveness of the creative learning experience [Design recommendations… 2013]. In addition, 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.

Conclusion

This project represents a strong "designerly way of thinking" by following the five key steps of Design Thinking. It responds to the research question *How can Design Thinking and Technology-Enhanced Learning be used to transfer knowledge and facilitate the exchange of ideas among learners?* with the two deliverables: a comprehensive "Creative Thinking tools reference guide" and a prototype section of an interactive online course focused on the design technique of Mapping. The reference guide was developed to support students from diverse backgrounds in the creative process, covering both the thinking / structuring and narrating / representing aspects. The introduction of the two-phase thinking model into the course is a methodological novelty in Design Thinking models, aimed at supporting learners from non-design backgrounds to develop visualization skills necessary for multidisciplinary communication. The guide synthesizes influential Design Thinking and Service Design methodologies 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 is in line with the survey findings that students have difficulty starting design projects and lack relevant examples. Finally, we concluded with the three strategies for transferring knowledge and facilitating the exchange of ideas among learners with different professional backgrounds:

1. Break down knowledge communication into small step-by-step instructions.

2. Emphasize the visual tools of knowledge transfer and research communication.

3. Implement multimodal knowledge communication to achieve better comprehension and engagement.

4. Use the AI-driven instructional videos to quickly produce and test the knowledge communication style and content.

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 student feedback, and to leverage AI-driven features to provide a more up-to-date support and guidance to learners. For instance,

 https://doi.org/10.21603/2782-4799-2024-3-3-191-202

we plan to experiment and create an AI-tutor trained on the course materials to help students answer their questions or even provide constructive feedback on their work at any time. However, using an AI assistant to generate a human-like tutor would raise the following research questions that need to be further explored:

1. Currently, the AI-driven image doesn't look natural; should we strive for a more natural look or create a clearly "robotic" or "artistic" image to provide transparency to learners about the origin of the knowledge? In other words, this question addresses the ethic of the AI.

2. What are the different values that a digital and a real tutor can offer to the learners?

3. Will the use of an AI-tutor have a positive or negative impact on engagement?

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

Conflict of interests: The authors declared no potential conflicts of interests regarding the research, authorship, and / or publication of this article.

Конфликт интересов: Авторы заявили об отсутствии потенциальных конфликтов интересов в отношении исследования, авторства и / или публикации данной статьи.

Contribution: All the authors contributed equally to the study and bear equal responsibility for information published in this article.

Критерии авторства: Авторы в равной степени участвовали в подготовке и написании статьи.

Acknowledgments: The authors express gratitude to XJTLU Teaching Development Fund and students of XJTLU Design School for supporting the initial research activities.

Благодарности: Авторы выражают благодарность Фонду развития преподавания XJTLU и студентам Школы дизайна XJTLU за поддержку начальной исследовательской деятельности.

References / Литература

Beghetto R. A., Karwowski M., Reiter-Palmon R. Intellectual risk taking: A moderating link between creative confidence and creative behavior? *Psychology of Aesthetics, Creativity, and the Arts*, 2021, 15(4): 637–644. https://doi.org/10.1037/aca0000323

Bezanilla M. J., Galindo-Domínguez H., Poblete M. Importance of teaching critical thinking in higher education and existing difficulties according to teacher's views. *Multidisciplinary Journal of Educational Research*, 2021, 11(1): 20–48.

Bonwell C. C., Eison J. A. *Active learning: Creating excitement in the classroom*. ASHE-ERIC Higher Education Report No. 1. Hoboken: Jossey-Bass, 1991, 128.

Brown T. *Change by design: How design thinking transforms organizations and inspires innovation*. HarperBusiness, 2009, 272.

Cai Yu., Yan F. Developing Chinese higher education in tensions, an conclusion. *Encyclopedia of educational philosophy and theory*, ed. M. A. Peters, Singapore: Springer, 2019. https://doi.org/10.1007/978-981-287-532-7_608-1

Clark R. E. *Learning from media: Arguments, analysis, and evidence*. 2nd ed. Charlotte: Information Age Publishing, 2012, 274.

Dam R. F., Teo Y. S. The history of design thinking. *Interaction Design Foundation*. 20 May 2022. URL: https://www.interaction-design.org/literature/article/design-thinking-get-a-quick-overview-of-the-history (accessed 30 May 2024).

Dell'Era C., Magistretti S., Cautela C., Verganti R., Zurlo F. Four kinds of design thinking: From ideating to making, engaging, and criticizing. *Creativity and Innovation Managemen*t, 2020, 29(2): 324–344. https://doi.org/10.1111/caim.12353

*Design recommendations for intelligent tutoring systems. Vol. 1. Learner modelin*g, eds. Sottilare R. A., Graesser A. C., Hu X., Holden H. Adelphi: US Army Research Laboratory, 2013, 277.

Glantz E. J., Gamrat C., Lenze L., Bardzell J. Improved student engagement in higher education's next normal. *EDUCASE Review*, 16 Mar 2021. URL: https://er.educause.edu/articles/2021/3/improved-student-engagement-in-higher-educations-next-normal (accessed 30 May 2024).

Kavousi S., Miller P. A., Alexander P. A. Modeling metacognition in design thinking and design making. *International Journal of Technology and Design Education*, 2020, 30: 709–735. https://doi.org/10.1007/s10798-019-09521-9

Kelley D. M., Kelley T. *Creative confidence: Unleashing the creative potential within us all*. NY: Crown Currency, 2013, 304.

Kirschner P. A., Karpinski A. C. Facebook and academic performance. *Computers in Human Behavior*, 2010, 26(6): 1237–1245. https://doi.org/10.1016/j.chb.2010.03.024

Lidwell W., Holden K., Butler J. *Universal principles of design*. Gloucester: Rockport Publishers, 2010, 272.

Lin M. F. G., Eichelberger A. Design thinking as a catalyst for change: Faculty reaction to a redesigned meeting. *Journal of Formative Design in Learning*, 2020, 4(1): 34–42. https://doi.org/10.1007/s41686-020-00046-2

Loyalka P., Liu O. L., Li G., Kardanova E., Chirikov I., Hu Sh., Yu N., Ma L., Guo F., Beteille T., Tognatta N., Gu L., Ling G., Federiakin D., Wang H., Khanna S., Bhuradia A., Shi Zh., Li Ya. Skill levels and gains in university STEM education in China, India, Russia and the United States. *Nature Human Behaviour*, 2021, 5(7). https://doi.org/10.1038/s41562-021-01062-3

Meyer M. W., Norman D. Changing design education for the 21st century. *She Ji: The Journal of Design, Economics, and Innovation*, 2020, 6(1): 13–49. https://doi.org/10.1016/j.sheji.2019.12.002

Micheli P., Wilner S. J. S., Hussain Bhatti S., Mura M., Beverland M. B. Doing design thinking: Conceptual review, synthesis, and research agenda. *Journal of Product Innovation Management*, 2019, 36(2): 124–148.

Moirano R., Sánchez M. A., Štěpánek L. Creative interdisciplinary collaboration: A systematic literature review. *Thinking Skills and Creativity*, 2020, 35. https://doi.org/10.1016/j.tsc.2019.100626

Powers M. N. *Self-regulated design learning: A foundation and framework for teaching and learning desig*n. 1st ed. London: Routledge, 2016, 230. https://doi.org/10.4324/9781315746081

Resnick M., Rosenbaum E. Designing for tinkerability. *Design, make, play: Growing the next generation of STEM innovator*s, ed. M. Honey. 1st ed. NY: Routledge, 2013, 163–181.

Silva G. D. E., Zancul E., Oliveira M. Comparative framework of models of design thinking process. *Economia Circular e Engenharia De Produção*: Proc. XXVII Symposium, Bauru, 11–13 Nov 2020. Online, 2020. URL: https://repositorio.usp.br/directbitstream/9af3bfdb-b9ef-4d67-8ba7-e5c66e84aecf/prod_24505-sysno_3043470.pdf (accessed 30 May 2024).

Taneri B., Dogan F. How to learn to be creative in design: Architecture students' perceptions of design, design process, design learning, and their transformations throughout their education. *Thinking Skills and Creativity*, 2021, 39. https://doi.org/10.1016/j.tsc.2020.100781

Varanasi R. A., Yan Sh., Toprani D., Borge M. *Making design practices visible to young learners*, 2020. https://doi.org/10.35542/osf.io/vxw4e

Zolotova M. L. *Creative Thinking tools reference guide for XJTLU UG design students and all interested*, 2024. https://doi.org/10.6084/m9.figshare.25602636.v4