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# Teaching Design Thinking Using Online Whiteboarding in a Graduate-level Digital Innovation Course

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**Abstract:** Design thinking has gained popularity in many tertiary education disciplines. However, the teaching of this topic and imparting students with the skills to improve their innovation competence are challenging tasks. In this paper, we examine the use of an online whiteboarding system as a platform to teach design thinking. The system was used by students in a graduate-level digital innovation course to complete their service design project. The project required them to generate IT-enabled service innovations by following the design thinking framework on the whiteboarding system. Results from 54 students show that online whiteboarding can be a very effective tool to develop design thinking skills. Additionally, we also investigate the relationships between the creative mindset of the learners and the different stages of design thinking. Our findings suggest that learners with growth creative mindsets report a higher level of perceived usefulness of whiteboarding as compared to fixed creative mindsets in terms of empathizing, defining and ideating stages of the design thinking process. The study is novel to the extent that it explores the use of online whiteboarding as a new learning platform to handle the challenging task of teaching design thinking and examines the relationships between learners' creative mindset and their perceptions of employing online whiteboarding in project-based learning.

**Keywords:** design thinking, service innovation, online whiteboarding, creative mindset, project-based learning

## 1. Introduction

Design thinking has emerged as a popular human-centered innovation process to bring about innovations in products and services (Lockwood, 2010). It has been defined as a process of '*creative strategies which designers utilize during the process of designing*' (Visser, 2006). Design thinking has gained prominence in recent years and many companies adopt this methodology to design not only products but also services and different kinds of solutions. IDEO, a company ranked as one of the most innovative companies in the world, is famous for applying the design thinking methodology to design various products, including health products, toys, food, electronics, computers, and different consumer goods. IDEO's CEO Tim Brown advocates design thinking as "*a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success*." Interestingly, IDEO is also applying the design thinking process to design services for financial, government and education sectors, and to come up with creative solutions for environment, investors, marketing, transportation and to enhance customers' experience among many other things (IDEO, 2015).

While the origins of design thinking date back to the 1960s, the term itself first appeared in a book titled 'Design Thinking' (Rowe, 1987). Multiple models of design thinking have emerged since then. However, the design thinking process, in general, should go through the five stages of *Empathize*, *Define*, *Ideate*, *Prototype*, and *Test*. During the Empathize phase, designers work to fully understand the experience of the users and try to empathize with the needs of the targeted audience. Next, the findings from the empathy work are processed and synthesized in the Define phase to form a user point of view and explain the problem in a human-centered manner. In the Ideate phase, designers brainstorm and explore a range of possible solutions. The design process is followed by

Prototyping phase where ideas are transformed into a more tangible form for users to experience and interact. Last, the Testing phase uses observations and feedback to refine prototypes and original point of view. It is important to note that design thinking is an iterative process of construction and reflection, and in many cases, the previous stages are not sequential.

The burgeoning interest in design thinking is reflected in the higher education domain, where a growing number of universities teach the design thinking methodology in order to equip tertiary students with the skills they need to handle innovative design tasks. Particularly, it has been increasingly adopted in management and engineering curriculums (Dunne & Martin, 2006; Dym, Agogino, Eris, Frey, & Leifer, 2005). The introduction of design thinking into the curriculum has mostly followed the pedagogical approach adopted by the Institute of Design at the Stanford University (d.school) and the currently most-favored pedagogical model for teaching design thinking is the project-based learning approach.

Although design thinking is increasingly been taught in many academic institutions around the world, it is still unclear how successful are these teaching programs and how can students learn design thinking more effectively (Dym et al., 2005)? Moreover, among the many emerging Web technologies, which are the ones that can be used to facilitate the teaching of design thinking? In this research, we attempt to address the aforementioned questions by proposing that online whiteboarding (OWB) system can be an effective tool to teach students design thinking skills. Unlike a physical whiteboard that designers use to sketch and scribble, OWB enables users to write, sketch, and add multimedia contents to a virtual board that can be accessed and shared anywhere from any device connected to the Internet. We use a graduate-level digital innovation course at a large Asian university as a research context to:

- examine the effectiveness of OWB in teaching design thinking skills;
- explore the relationships between the learners' creative mindset and their perceptions of using the online whiteboarding environment in their design thinking project.

## *1.1 Design Thinking in Education*

The pedagogical value of design thinking in the learning context is seen as an ongoing cycle of generating ideas (abduction), predicting consequences (deduction), testing, and generalizing (induction) (Johansson-Sköldberg & Woodilla, 2013). This design process has both analytic and synthetic elements, and it operates in both the theoretical and practical realms. In the analytic phases of design, learner focuses on finding and understanding, while in the synthetic phases of design, learner focuses on invention and making (Beckman & Barry, 2007).

In fact, it is apparent that by going through all five stages of the design thinking process, learners can potentially hone and sharpen their competencies in all four critical skills that have been identified as the most important skills required for 21st-century education, also known as the Four Cs (National Education Association, 2014), namely:

- Critical thinking,
- Communication,
- Collaboration, and
- Creativity

In other words, preparing students who can adopt design thinking may help in creating 21st--century-ready students who are able to identify problems and analyze situations, devise innovative ways to solve problems, effectively convey ideas and information to others, and work well in a team. Additionally, adopting design thinking in the learning process may serve different types of goals. It can consolidate goals related to *emotional and motivational abilities* that students should develop, it can also help in *explicit knowledge transfer* and it can strengthen various *competencies and skills* of the students, including soft and hard skills (Rauth, Köppen, Jobst, & Meinel, 2010).

According to Rauth et al. (2010), the basic principles of design thinking education include focusing on people as a source of inspiration for solving design challenges by experiencing the feelings, thoughts, and attitudes of others. This process tries to discover individuals' explicit and implicit needs while keeping a critical mindset. A design thinking education also tries to inculcate a prototyping and experimental culture where ideas grow and are communicated using visualization, sketching, prototyping, digital communication, and storytelling. Students should master these skills

while working with diverse team members where confronting team dynamics may lead to greater innovation. In fact, some researchers have also situated gamification as one design thinking process into the context of creativity and shared understanding of innovation challenges in organizations (Roth, Schneckenberg, & Tsai, 2015; Schulz, Geithner, Woelfel, & Krzywinski, 2015).

### *1.2 Design Thinking and Online Whiteboarding (OWB)*

It is important to distinguish between online whiteboards and electronic physical whiteboards, usually called interactive whiteboards (IWBs). IWBs appeared a long time ago and were examined in many prior studies. Some of these studies have shown positive learning outcomes in classrooms (Smith, Higgins, Wall, & Miller, 2005). On the other hand, to the best of our knowledge, the topic of online whiteboarding in learning received limited attention in the education literature.

An IWB is a big computer touchscreen or a board with sensors that is used as a mega touchpad to control computers while graphics from the computer are shown on the screen or projected on the board using a projector. These interactive whiteboards are already used widely in offices and schools. On the other hand, OWB is a Web 2.0 learning technology that runs directly in the Web browser, without the need to install any software, and it uses line, shape, and text tools to structure illustrative processes (Bower, 2016). Many OWB platforms also offer various collaboration capabilities among users.

According to the VARK model, learners can be classified as visual, auditory, read/write or kinesthetic learners (Fleming & Mills, 1992). When considering these various styles of learners, we may anticipate that the rich, visual environment offered by an OWB can be very effective especially for visual learners since they prefer information to be depicted in diagrams, charts, patterns, and shapes instead of in words. More specifically, when it comes to people with visual thinking capabilities, some earlier studies showed that IWBs can be used as effective tools to think and communicate ideas visually (Walny, Carpendale, Riche, Venolia, and Fawcett, 2011). We expect this to also apply to OWB.

Furthermore, based on the constructivist learning theory, learning is essentially a process of constructing meaning by the learners. The theory looks at learning as an active and contextualized process involving mental and social activities. We contend that OWBs are powerful platforms to construct knowledge while collaborating with other learners or designers. In fact, earlier studies showed that IWB enables learners to learn by jointly constructing meaning (Twiner, 2010). Hence, we consider OWB to be similar or even more effective than IWB in this sense.

## 2. Research Method

### *2.1 Research Context*

In using OWB to teach design thinking, we expect that learners' creativity can be augmented when they work on their designs in a gamified, visual OWB environment. We chose RealtimeBoard®, which is one of the most popular online whiteboarding solutions available in the market. We decided to use RealtimeBoard in our class because it offers a design-centric workflow and many templates that fit with the design thinking stages.

RealtimeBoard allows team members to ideate, innovate, share ideas and work together online. It offers one visual space for geographically distributed team members to work together. Users can build diagrams, create flowcharts, draw mind maps and embed files and multimedia contents. Users can also vote on ideas and exchange feedback using the system. They can show presentations right from the website, share their screen, handle text/video chats and track the activity of other members. The platform provides users with the ability to engage in visual storytelling and to create interactive prototypes of their proposed designs.

Figure 1 shows some of the many RealtimeBoard templates that can serve different design purposes, including user story mapping, Kanban boards, mood boards, empathy maps, value chains and mind maps among many others.

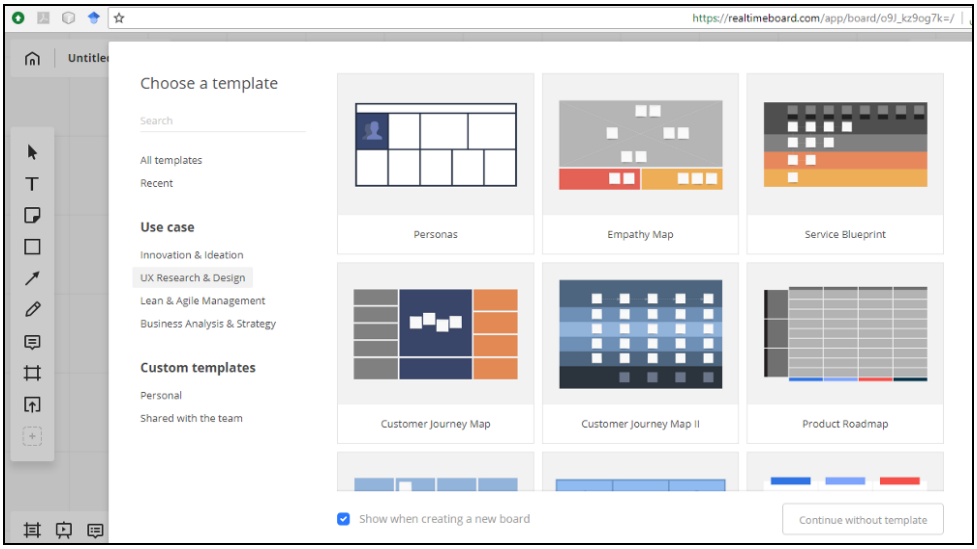


*Figure 1.* RealtimeBoard offers many templates that fit the design thinking stages

## *2.2 Data Collection*

In this study, we analyzed data collected from a graduate Master-level digital innovation course for two semesters in a large Asian university. In the course, students were taught design thinking principles and they were required to adopt the design thinking approach to work on a team project using an OWB platform. The students worked in teams of three to six to redesign the service system for a service organization of their choice.

The project was about redesigning a service system for a service organization of their choice. Students were required to apply design thinking stages they learned during the course in order to design service innovations for the organization. Students used the *empathy map* and *personas templates* in the RealtimeBoard to address the *empathy* stage in design thinking. The *customer journey map* template was used for the *define* stage. For the *ideation* stage, students' teams used *mind maps* to brainstorm and generate new ideas. Finally, for the *prototyping* stage, students used *wireframing templates* to design the user interface of their Website/mobile app. Because of time constraints in the 13-week course, we did not require students to develop a functioning system or to *test* their proposed solutions. Some examples of students' submissions are shown below in Figures 2, 3, 4, and 5.

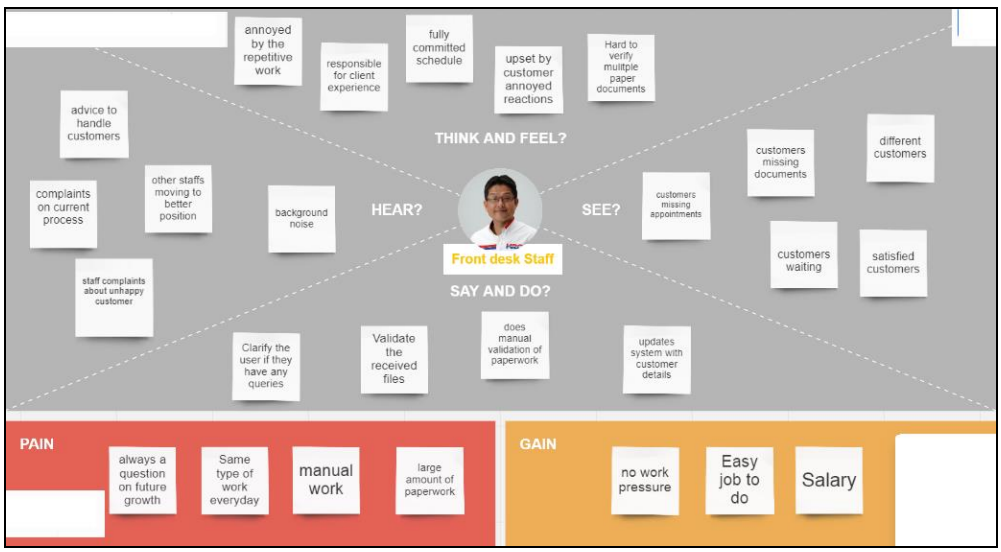


*Figure 2.* Empathy map

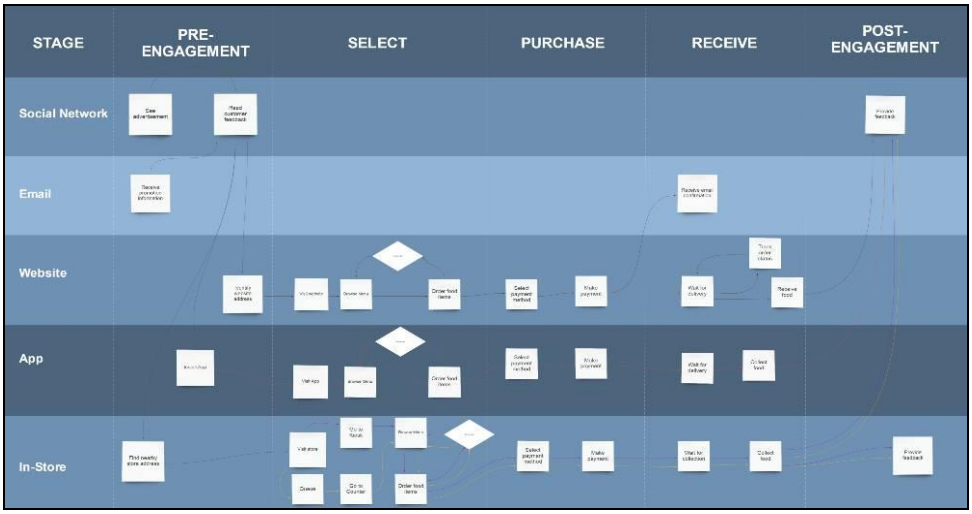


*Figure 3.* Customer journey

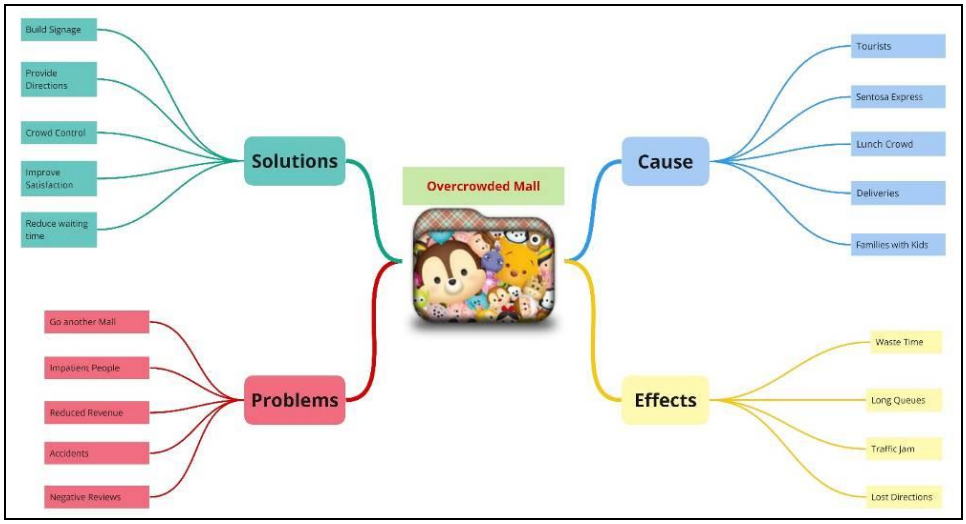


*Figure 4.* Mind map

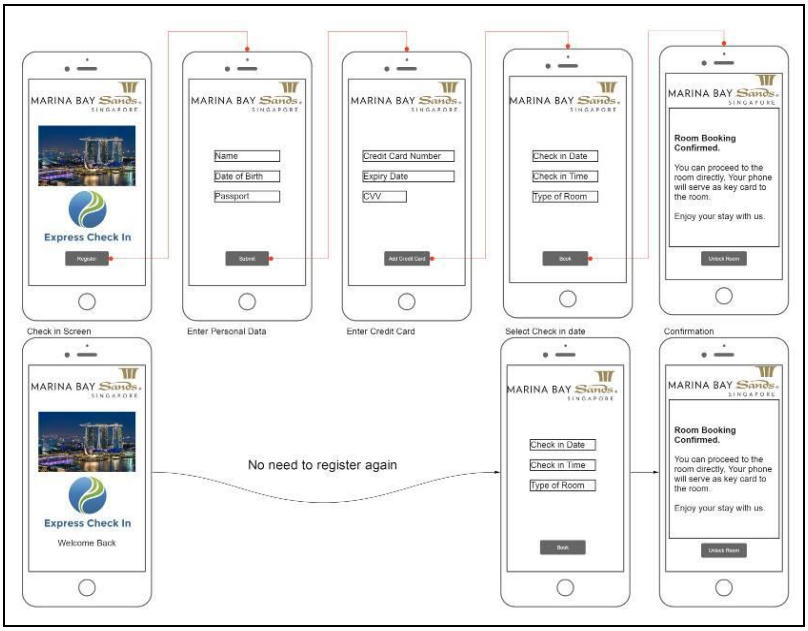


*Figure 5.* Wireframing of mobile app interface

Students completed two online surveys at the start and end of the course. For the first survey, we received 59 responses and for the second survey, we received 56 responses. The first survey was administered to assess the creative mindsets of the students. The creative mindset can be defined as beliefs about the stable-versus-malleable character and the nature of creativity (Karwowski, 2014). In order to study creative mindsets we have to distinguish between inborn (fixed) versus learnable (growth) creative mindsets. Another two variables of interest in this study are creative self-efficacy (CSE) and creative personal identity (CPI). Earlier studies showed that a fixed creative mindset is negatively correlated with the growth creative mindset and that people with a fixed mindset usually employ more helpless strategies (Hass, Katz-Buonincontro, & Reiter-Palmon, 2016).

The first survey used a 5-point Likert scale that ranges from "Definitely Not" to "Definitely Yes". It included the 10-item scale to measure the creative mindsets (fixed vs growth mindset) (Karwowski, 2014), in addition to the 11 items from the Short Scale of Creative Self (SSCS) which is used to measure CSE and CPI (Karwowski, 2014). The items in this survey are shown in Table 1.

Table 1. *Items of the First Survey*

| Factor | Item | Item Description |
|---|---|---|
| **Creative Self-efficacy** | CSE1 | I know I can efficiently solve even complicated problems |
| | CSE2 | I trust my creative abilities |
| | CSE3 | Compared with my friends, I am distinguished by my imagination and ingenuity |
| | CSE4 | I have proved many times that I can cope with difficult situations |
| | CSE5 | I am sure I can deal with problems requiring creative thinking |
| | CSE6 | I am good at proposing original solutions to problems |
| **Creative Personal Identity** | CPI1 | I think I am a creative person |
| | CPI2 | My creativity is important for who I am |
| | CPI3 | Being a creative person is important to me |
| | CPI4 | Creativity is an important part of me |
| | CPI5 | Ingenuity is a characteristic which is important to me |
| **Growth Mindset** | GROWTH1 | Everyone can create something great at some point if he or she is given appropriate conditions |
| | GROWTH2 | Anyone can develop his or her creative abilities up to a certain level |
| | GROWTH3 | Practice makes perfect—perseverance and trying hard are the best ways to develop and expand one's capabilities |
| | GROWTH4 | Rome wasn't built in a day—each creativity requires effort and work, and these two are more important than talent |
| | GROWTH5 | It doesn't matter what creativity level one reveals—you can always increase it |
| **Fixed Mindset** | FIXED1 | You either are creative or you are not—even trying very hard you cannot change much |
| | FIXED2 | You have to be born a creator—without innate talent you can only be a scribbler |
| | FIXED3 | Creativity can be developed, but one either is or is not a truly creative person |
| | FIXED4 | Some people are creative, others aren't—and no practice can change it |
| | FIXED5 | A truly creative talent is innate and constant throughout one's entire life |

The second survey, administered at the end of the course, assessed whether OWB (RealtimeBoard in our case) is effective in enhancing students thinking and creativity in general, and whether it facilitates the adoption of the design thinking approach in terms of empathizing with customers, defining the problem, ideating new solutions and prototyping the proposed solution. This survey also explored the students' perceptions regarding using RealtimeBoard to collaborate and communicate ideas. The survey comprised of 11 self-developed items anchored on a 7-point Likert scale that ranges from "Strongly Disagree" to "Strongly Agree".

We performed Fisher's Exact test and Chi-Square test to ensure that there are no significant differences in the sample between the two semesters. After combining the responses of students who completed both surveys, we were left with 54 matched responses for the final pooled sample. Details of the data collected are shown in Table 2 below.

Table 2. *Descriptive Statistics of the Sample*

| **Course Semester** | **Total no. of students in class** | **No. of teams (projects)** | **No. of responses for Survey 1 (response rate)** | | **No. of responses for Survey 2 (response rate)** | | **Matched responses for the two surveys (response rate)** | |
|---|---|---|---|---|---|---|---|---|
| 2016/2017 Semester 2 | 24 | 8 | 24 | 59 (95.2%) | 23 | 56 (90.3%) | 23 | 54 (87.1%)* |
| 2017/2018 Semester 2 | 38 | 8 | 35 | | 33 | | 31 | |

*$\chi^2$ =2.659, *df* =1, *p*-value = .103

## 3. Data Analysis and Results

Results from the first survey (students' creative mindsets and self-concept) suggest that the students reported higher scores on the growth creative mindset, CPI, and CSE in comparison to fixed creative mindset. Based on this, we see that our student sample possesses a stronger growth mindset relatively to a fixed mindset. Descriptive results are shown in Table 3 below.

Table 3. *Results of the First Survey of CSE, CPI, Growth and Fixed Mindsets*

| **Factor** | **Item** | **Item Average*** | **Factor Average** | **S.D.** |
|---|---|---|---|---|
| CSE | CSE1 | 3.95 | 3.99 | 0.78 |
| | CSE2 | 4.08 | | |
| | CSE3 | 3.63 | | |
| | CSE4 | 4.27 | | |
| | CSE5 | 4.03 | | |
| | CSE6 | 3.95 | | |
| CPI | CPI1 | 3.97 | 4.07 | 0.87 |
| | CPI2 | 4.00 | | |
| | CPI3 | 4.32 | | |
| | CPI4 | 4.08 | | |
| | CPI5 | 4.00 | | |
| GROWTH | GROWTH1 | 4.08 | 4.10 | 0.89 |
| | GROWTH2 | 4.10 | | |
| | GROWTH3 | 4.31 | | |
| | GROWTH4 | 4.02 | | |
| | GROWTH5 | 4.00 | | |
| FIXED | FIXED1 | 2.24 | 2.52 | 1.21 |
| | FIXED2 | 2.12 | | |
| | FIXED3 | 3.24 | | |
| | FIXED4 | 2.03 | | |
| | FIXED5 | 2.95 | | |

* Scores are out of a maximum of 5

By analyzing the data from the second survey (students' feedback about using RealtimeBoard), we find that students believe OWB to be very effective in enhancing their abilities to collaborate and communicate their ideas within innovative design projects and it provided a structured way to facilitate their adoption of the design thinking approach. Results of the analysis are shown in Table 4 below.

Table 4. *Results of the Second Survey*

| **Design Thinking Stage/Competence** | Empathize | Define | Ideate | Prototype | Collaborate | Communicate |
|---|---|---|---|---|---|---|
| **Average*** | 6.02 | 6.04 | 5.92 | 6.01 | 6.21 | 6.18 |
| **S.D.** | 1.46 | 1.50 | 1.45 | 1.46 | 1.46 | 1.45 |

* Scores are out of a maximum of 7

Finally, we tried to investigate the relationships between different creative mindsets among our students and their perceptions towards the usefulness of online whiteboarding as a tool for design thinking. Correlational results showed that students with growth creative mindset reported higher scores on the usefulness of online whiteboarding in terms of empathizing, defining and ideating stages of the design thinking methodology. Results are shown in Table 5 below.

Table 5. *Correlation Matrix Showing the Relationship Between Different Creative Mindsets Factors and the Stages of Design Thinking*

| | | CSE-AVG | CPI-AVG | GROWTH-AVG | FIXED-AVG |
|---|---|---|---|---|---|
| Empathy Avg | Pearson Correlation | .043 | .114 | **.336*** | -.102 |
| | Sig. | .756 | .412 | .013 | .462 |
| | N | 54 | 54 | 54 | 54 |
| Define Avg | Pearson Correlation | .061 | .126 | **.269*** | -.045 |
| | Sig. | .661 | .362 | .049 | .745 |
| | N | 54 | 54 | 54 | 54 |
| Ideate Avg | Pearson Correlation | .055 | .079 | **.295*** | -.007 |
| | Sig. | .694 | .572 | .030 | .960 |
| | N | 54 | 54 | 54 | 54 |
| Prototype Avg | Pearson Correlation | .032 | .163 | .203 | -.039 |
| | Sig. | .816 | .238 | .141 | .777 |
| | N | 54 | 54 | 54 | 54 |

* Correlation is significant at the 0.05 level

## 4. Discussion and Future Research

In this study, we explored the use of the relatively new technology of online whiteboarding in the learning of design thinking skills. Our findings show that online whiteboarding is a promising technology that has positive impacts on students' learning of design thinking.

Results suggest that OWB is very effective in enabling students to collaborate and communicate their ideas and to follow through the various stages of the design thinking framework. Broadly speaking, we have some evidence that OWB can be a very effective educational tool to attain the four 21st-century C-skills (critical thinking, communication, collaboration, and creativity).

From a practical perspective, our findings provide some empirical support for the wider deployment of OWB at the tertiary education level, especially for innovation-related courses that involve the teaching of design thinking. We believe that adopting such technology is not difficult and is inexpensive because OWB does not require special devices and some of OWB systems are available cost-free. In addition, OWB can potentially offer an interesting, motivating, and fun learning experience for learners that is often lacking in higher education.

The other important finding in our study is that students with growth creative mindset are more likely to perceive the usefulness of OWB during at least the first three stages of design thinking (empathizing, defining and ideation). When it comes to the fourth stage, prototyping, the correlation was not significant. One possible explanation is that the wireframing template we used may be too simple and not that efficient to perform the prototyping stage. Another plausible explanation is that OWB seems to be more effective in supporting the initial stages like defining the problem or generating innovative solutions than in supporting the latter stage of developing a prototype. Nevertheless, these results suggest that course instructors may investigate and gain some preliminary understanding of the different creative mindsets of their students before customizing their course contents and assignments. For example, if the students have a fixed creative mindset, this may suggest the instructor should avoid using the OWB.

Overall, the results presented in this study can be used as a cornerstone in the future to develop a general model for employing OWB as a tool to teach design thinking. Further studies can collect qualitative feedback from students. Such qualitative feedback may enable us to explore team dynamics within creative design projects and students' perceptions regarding their experiences using OWB in comparison to working on other team projects they had in other courses. Next, the students' project submissions can also be analyzed for more objective measures of learning outcomes. This should give us further insights into the usefulness of OWB systems and may enable us to evaluate the outcomes of using OWB in comparison to other educational tools. Furthermore, we believe that the activity tracking capabilities offered by some OWBs are worth studying. We expect that the existence of a timeline or a log for all activities not only enable the instructor to track students' performance but may also encourage students to collaborate more actively. This granular tracking feature could be one of the important advantages offered by some online learning systems and may be a strong deterrence for free-riders, who represent a big problem in any collaborative working environment.

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