Using design thinking at the Japanese university
― for innovation and entrepreneurship education ―

by
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Abstract

This paper takes a radical review at the design thinking, to identify the features and characteristics of design thinking and promote students' problem-solving skills regarding the application of design thinking to the Japanese educational system. Then try to build a model to introduce innovation and entrepreneurship curriculum using design thinking process, based on empathy, identify, ideate, prototype, test. Design thinking is increasingly used to mean the human-centered, open problem-solving procedure, it is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign. The model has been implemented to build a secure program as a method to understand innovation and entrepreneurship and achieve the course objective and outcomes. The assessment of this method shows the high level of student engagements, collaboration, research, and presenting ideas and thoughts.

Key Words：design thinking, design process, innovation and entrepreneurship education.

1. Introduction

Design thinking has become an essential part of the design and engineering fields as well as business models, events, job role definitions, recruitment processes, strategies, internal processes, among others (Schmiedgen et al., 2015), it can also have a positive influence on 21st century Japanese university education across disciplines because it involves creative thinking in generating solutions for problems. Normally, in academic environments, students are required to read critically, think and reason logically, and solve complex problems (Rotherham & Willingham, 2009).

The principle behind introducing design thinking was to mature the students' abilities for conceptualizing and approaching creative challenges, and in the process engage with potential end users in order to create artifacts that closely meet those people's needs and desires rather than those of the student.

Thus, in order to help students succeed in this interconnected, digital world we live in, educators should support students in developing and honing 21stcentury skills (e.g., design thinking, systems thinking, and teamwork skills) that enhance their problem-solving skills and prepare them for college and career (Rotherham & Willingham, 2009; Shute & Torres, 2012).

However, there are a consistent set of challenges that educators and universities or schools seem to face, and they center around the design and

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development of learning experiences (curriculum), learning environments (spaces), school programs and experiences (processes and tools), and system strategies, goals, and policies (systems).

So that, effectively apply design thinking approaches in university education, methods, and principles an extensive theoretical research was conducted. The main purpose of this paper is to identify the features and characteristics of design thinking and show its importance in promoting students' problem-solving skills needed to succeed in the Japanese university, in particular, innovation and entrepreneurship curriculum. The major questions addressed to: (1) what are the characteristics of design thinking, (2) what are the differences between a beginner and an expert design thinker, and (3) why is design thinking important.

To accomplish the purpose of the study, summarizing findings from the literature of design thinking to gain the better understanding of its characteristics, processes, and differences between novice and expert design thinkers. Meanwhile, applying the findings from the literature regarding design thinking to our educational system.

2. Literature Review

2.1 Approach of design thinking

The phrase "design thinking" was popularized by Rowe (1991) to refer to the ways in which designers approach design problems, although design researchers have been studying the process for decades (Schon, 1983; Simon, 1969). The design has been widely considered to be the central or distinguishing activity of engineering (Simon, 1996). It has also been said that engineering programs should graduate engineers who can design effective solutions to meet social needs (Evans, McNeill & Beakley, 1990). Currently, the term refers to both conventional design domains as well as in different contexts such as business (Brown, 2009; Martin, 2009) and computing (Brooks, 2010). Despite such different uses and application, design thinking can be described as a grounding framework for multidisciplinary teams to communicate and to coordinate activity (Lindberg et al., 2010).

Since design thinking as a way of creative action that was adapted for business purposes by IDEO through David M. Kelley. Design thinking as design company IDEO's way of working with design and innovation (Kelley, 2001, 2005; Brown, 2008, 2009). Brown (2008) stressing three basic properties of the new design thinking approach: design thinking is equally relevant for designing products and spaces as well as systems or services; the primary goal of design thinking is disruptive innovation to gain competitive advantage on the global market; design thinking is human-centered, and as such, can be done by different people other than designers.

Moreover, in the academic environment, the Hasso Plattner Institute of Design at Stanford University characterized design thinking as a human-centered and prototype-driven process for innovation that can be applied to product, service, and business design (Hasso Plattner Institute of Design at Stanford in Cohen, 2014). In other words, design thinking can be considered as a methodology to actualize concepts and ideas (Cohen, 2014).

As an approach, design thinking taps into capacities we all have but that are overlooked by more conventional problem-solving practices. Not only does it focus on creating products and services that are human-centered, but the process itself is also deeply human. Design thinking relies on our ability to be intuitive, to recognize patterns, to construct ideas that have emotional meaning as well as being functional, and to express ourselves in media other than words or symbols. Design thinking, the integrated approach at the core of the design process, provides a third way.

Design thinking that leads to design a product, a service, or else, based on the conclusions of the knowledge gathered in the processes.

Thus, design thinking is to ask students to become and convert into investigators in their world, attempt

to solve problems, bridge and overpass the gaps of knowledge independently, collaboratively, and resourcefully. These are skills that are highly relevant in today's job market (Gray, 2013).

Modern education depends on a diversity of different sources of information for discovery and picture conclusions. Between these sources are various media such as videos, podcasts or text. Experts in the community can also be sought to convey information to students. In design thinking, students learn more about the problems they are trying to solve. They do this by going on field trips or by visiting an expert in a lab, workshop, or studio (McKendrick, 2013).

2.2 Characteristics of design thinking

Design thinking is a cross-disciplinary creative problem-solving process which combines analytical thinking, creative thinking, and practical skills (Ingalls Vanada, 2011). Design thinking is an approach to learning that involves hands-on learning projects, focusing on inquiry and problem solving, investigation of possible solutions, sketching and prototyping, collaboration and feedback, created 'products' or ideas, as well as reflection and redesigns if necessary (Razzouk et al., 2012).

In order to establish a full understanding of design thinking, there is considerable empirical work to be done.

Entrepreneurs include Bill Gates, Steve Jobs, Mark Zuckerberg, commonly have characteristics such as risk-taking, self-confidence, a need for achievement, the high internal locus of control, desire for autonomy, creativity, and opportunism. They apply more intuitive and holistic approaches which require more synthesis, lateral reasoning, and unsystematic exploration. These features are reflected in entrepreneurs' inclination towards achievements through non-conventional thinking, to challenge prevailing assumptions, as well as be flexible and adaptable when solving problems (Kirby, 2004).

Badke-Schaub, Roozenburg and Cardoso (2010) suggested one possibility is to describe the essentials of the concept as a list of characteristic elements. They have done identified creativity, visual thinking, reasoning and expertise as characteristics of design thinking. This set of characteristics are based on thinking processes such as information search and generation, mental imagery, assessment and evaluation, structuring and learning (Goldschmidt & Badke-Schaub, 2010).

Likewise, other authors (Armstrong, 2013; Core elements, 2014; Owen, 2006) highlight a further list of qualities that design thinking requires. Although these characteristics include a human-centered approach, they go beyond creativity. They emphasize a more constructive approach to the design thinking process. These features and ways of working are as followed.

Human-Centered.

Design thinking begins from deep empathy and understanding of needs and motivations of people. Designers must continually consider how what is being created will respond to human needs.

Collaborative.

Several great minds are always stronger when solving a challenge than just one. Design thinking benefits greatly from the views of multiple perspectives, and others' creativity bolstering your own. According to Wylant (2010), design thinking is the discipline of cycling through many contextual exercises of placements to understand how sense can be made of something and given this, the designer is then in a position to choose which contexts should dominate and the manner which they should have. The notion of placements in response to worked problems dissolves the boundaries between modernist and postmodernist design thinking. Designers need to develop interpersonal skills that allow them to communicate across disciplines and work with other people.

Optimistic.

Design thinking is the fundamental belief that we all can create change ― no matter how big a problem, how little time or how small a budget. No

matter what constraints exist around you, designing can be an enjoyable process.

Experimental.

Design thinking gives students permission to fail and to learn from their mistakes, because students come up with new ideas, get feedback on them, then iterate. Due to design thinking as a way of reasoning or making sense of things (Lawson, 2006; Cross, 2006, 2011). Yet there is an underlying expectation that educators must strive for perfection, that they may not make mistakes, that they should always be perfect role models. This kind of expectation makes it hard to take risks. It limits the possibilities to create more radical change. But educators need to experiment as well, and design thinking is all about learning by doing.

In conclusion, design thinking is the confidence that new, better things are possible and that you can make them happen. And that kind of optimism is well-needed in education.

2.3 Process of design thinking

Studies have included observation, interpretation, and analysis of individuals' design process (Cross, 2001; Oxman, 2004).

On the other hand, the five-step process (Figure 1.) proposed by Hasso Platner (2006) operationalizes design thinking, providing a prescriptive process. The five-step process moves through from empathizing to defining, ideating, prototyping, and testing.

Through empathizing and defining the designer can begin by understanding what users really want and develop an accurate problem statement. Ideation promotes generating as many ideas as possible. Only after ideas are generated are they balanced with the design constraints. Prototyping and testing generate user data to inform the process. In particular, this process is an iterative process (Burnett, 2016).

The five-step design thinking process help designers overcome the "fear of failure" because the understanding of the real users issues elicited from the empathize and define steps allows designers to build ideas on a solid foundation (Kelley & Kelley, 2006). The test mode is another iterative mode in which we place our low-resolution artifacts in the appropriate context of the user's life.

Regarding to a team's solution, designers should always prototype as if they know they're right, but test as if they know they're wrong, testing is the chance to refine our solutions and make them better. Designers are encouraged to ideate without thinking about limits, and to use prototyping and testing as a feedback loop to continue improving the design.

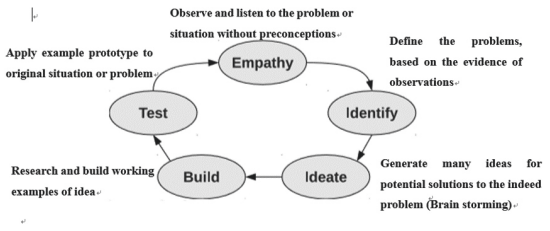

Fig 1. Design thinking process

The first process within design thinking is empathy. Empathy arises from a deep understanding of the users and their needs. It goes beyond merely involving users in a design process and considering their articulated wants and needs: in this model, empathy requires an anthropological approach to understanding users and their environments (Gestwicki & McNely, 2012). Empathy is the ability to accurately perceive what someone else is feeling or experiencing (Gasparini, 2015; Kouprie & Visser, 2009). In design thinking, empathy is the first step because it allows the designers to understand the culture and context where the problem originates, which helps to reduce the biases and preconceptions for designers, and they may place their perspective in the current world. Three main techniques are used to gain empathy: interviewing, observation, absorption. The goal of the empathy mode is to discover gaps in between what people do and what people say they do. These gaps are the design opportunities.

The second step is to clearly define the problem statement as a 'narrowing' part of the process. Designers synthesize the needs and insights they

obtained from the previous step and develop an inventory of users needs and desires (Kembel, 2009). The previous step of empathizing helps to create a state of mind and brings new knowledge into the process of defining the problem. Identifying the problem is the step that directs the subsequent efforts of the designers to solve the underlying root issues.

The third step in the five-step design thinking process is to ideate possible solutions. Ideation is the process of idea generation. The accuracy on the previous two steps, empathize and define, is essential for the success of ideation because here is where designers generate solutions to address the problem defined before. In ideation, designers are encouraged to bring as many ideas as possible, without considering if the solutions are feasible. The goal is to cross the limits of traditional design (Kembel, 2009). With all the ideas on the table, designers should proceed to balance them among the multiple dimensions and constraints of user desirability, technical feasibility, and resource constraints. There are many techniques to develop creative ideation (Goldenberg et al., 1999; Jonson, 2005) and also to measure the effectiveness (Shah et al., 2003) of the ideation processes. Ideation provides the fuel for building prototypes and driving innovative solutions.

The fourth step as prototyping the selected solutions is a central activity for innovative and creative design, allowing designers to build hypothesized solutions. The act of prototyping implies building, testing, and iterating and is, itself, both a flaring and a narrowing process. Prototyping helps frame the problem into a thinking-by doing methodology (Hartmann et al., 2006). The feedback obtained from users when they are testing a product or service is much richer because users can see what the future looks like, which improves the quality of data to feed the design. Prototyping in design thinking also reduces the fear of failure on designers because they build the potential solutions early in order to get information. David Kelly (2006) defines this step as failure immunity because designers see prototyping success or failure as a mechanism to enrich the design process. The potential solution is then put to the users for them to test.

The last step as testing gathers feedback about how well the prototype meets the needs of the end user (Razzouk & Shute, 2012). The solution provided to the users is finalized in this step. However, design thinking is an iterative process, which means that if the result of the solution is not satisfactory, the process does not end but goes back to one of the previous phases, repeating each step as many times as necessary (Dym et al., 2005).

3. Design thinking in university education

3.1. Examples of design thinking in university education

Expert designers are solution focused rather than problem focused. This appears to be a feature of design thinking that comes with education and experience in designing (Cross, 2004). Specifically, helping students to think like designers may better prepare them to deal with difficult situations and to solve complex problems in school, in their careers, and in life in general.

Meanwhile, Mislevy, et al. (2011) have found no valid performance-based assessments of design thinking skills. This lack adversely affects the ability to collect good evidence about the effects of these skills on learning (Rotherham & Willingham, 2009). Mislevy, et al. (2011) also suggested employing the evidence-centered design (ECD) framework (Mislevy, et al., 2003) for designing valid performance-based assessments for 21st-century skills. ECD is a systematic approach to the design of assessments that focus on the evidence (i.e., student performance and products) of proficiencies as the basis for constructing assessment tasks and making inferences about competency levels. ECD is especially suited for assessments that involve complex problems and dynamic, interactive environments ― which are exactly the kinds of

contexts required for design problems. Eagen et., (2011) state that in response to a demand for innovation, business programs are emerging which embrace multi-epistemic modes of design thinking. They explore the pedagogical models used to teach design thinking in business programs and identify multiple ways of knowing including (capabilities), cognition, emotion, sensation, and intuition as central to design thinking.

Currently, Gestwicki and McNely (2012) presented a case study in the design of an educational video game about collecting, curating, and museum operations. There are four key findings from their team's practice-based research: (a) that empathy for learning context is critical; (b) that meeting with stakeholders spurs empathy-building; (c) that there is a tension between horizontal and vertical slicing that is revealed by design thinking processes; and (d) that iterative design processes challenge conventions of higher education.

In the UK, the students followed Stanford University's d.school five-step approach of Empathize-Define-Ideate-Prototype-Test.

Fabri (2015) observed that initially students found the design thinking approach counter-intuitive and confusing, yet on further progress, they recognized the strengths and opportunities it offers. Generally, students reflected positively on their learning and the re-evaluation of their role as a designer of digital artifacts. Lessons learned from a teaching point of view are outlined, the most moving being the realization that it was required to 'unteach' certain design practices students had come to adopt, especially, the view of design as a self-inspired process where users are consulted for feedback but not as a source for innovation.

In Japan, Fujitsu has championed the 'Design Thinking for Future Schools Project' where cross-disciplinary teams have used a design thinking model to assist educators to re-engineer learning experiences that fully integrate ICT in non-traditional ways (Takeda, 2013).

Furthermore, Akpinar, et.al. (2015) observed student designers as they worked in a design studio and examined the documents they produced. Students' design thinking process, the relationships between the quality of their processes, and the quality of the students' design products were examined. Their study revealed that students generally follow the basic steps of the design processes. Examination of the students' quality of the processes and design products showed that a student who follows a better design processes may have a better design product.

3.2 Design thinking in innovation and entrepreneurship education

Rowe (1994) emphasized the significance of design thinking in design education and explored the cognitive process of design. It is widely agreed that previous studies of the design thinking are important since it helps to develop more cultured approaches of design pedagogy (Schon, 1985; Eastman, 1999). Kellogg (2006) claimed that students are invited to bridge the gap between subjective and objective reasoning by using intuitive analytics (or the ability to combine ideas and common sense into a new whole).

Stolterman (2008) stated that design disciplines such as interaction design have to develop and foster their own approach to education and practice.

Since the development of d.school (design thinking school) from the Hasso Plattner Institute of Design at Stanford University. Based on methods of engineering, design, the arts, social sciences, and business, design thinking courses aim to develop solutions to a number of real-world challenges in innovative and human-centered ways (Hasso Plattner Institute of Design at Stanford, 2012). The origins of the first d.school come from Stanford in 1958 by establishing a Product Design major and the graduate-level Program in Design (History, 2016). It was the time when Professor John Arnold proposed for the first time the idea that design engineering should be human-centered and applied to education. In recently, the more relevant

managerial education is to the needs and realities of contemporary business and society, the less future entrepreneurs will be discouraged to obtain the business education (Neck & Greene, 2011).

Thus, design thinking in higher education can be easily compared to experimental learning tools and techniques. It was combined with traditional teaching and learning can foster the creation of stronger links between theories and practices. It pays more attention to students' expression of ideas and performance through active engagement in the learning process.

4. Applied design thinking in university education

4.1 Work settings to processes of design thinking and student expectation outcomes

According to Kolb and Kolb (2005), the major changes can be introduced to management education through design thinking include: better theory-practice integration, less focus on linear argumentation, more focus on students' performance, expressions of students' skills and ideas, more individualized attention and introduction of diverse learning styles (Kolb & Kolb, 2005). Meanwhile, design thinking is aligned with active and experiential learning; it has long focused on processes familiar to students in schools of art and architecture: the posing of a problem which is ambiguous or open-ended, with some constraints (Kellogg, 2006). Thus, for educators, design thinking requires a pedagogical shift (Daichent, 2011) toward learning that is: 1) human-centered; 2) action-oriented; and 3) process-oriented (Carroll et., 2010).

Based on the previous study, this section framing of a design thinking challenge sets of each step for students to explore characters and problems within a situation. It was concluded as follows.

Process 1. Empathy

Before teamwork: Educators to provide a range of empathy experiences (varying perspectives as well as activities allow for stories, feelings, problems etc...)

During teamwork: Students should use follow-up questions, students diligently records (notes, video etc.) people's responses.

After teamwork: Students have collected diverse empathy artifacts (stories, pictures etc...).

Expectation outcomes:

- The value of building empathy to discover deeper needs.
- Skills needed to understand user

Process 2. Identify/Define

Before teamwork: Students have a range of information including quotes, picture/drawings, descriptions of users' feeling. Students have a space to share findings i.e. whiteboard, tabletop, floor.

During teamwork: Students should seek patterns in the information, form user profits, detect implicit and explicit needs, capture surprising behaviors and feelings.

After teamwork: Capture a unique user, need, and insight from all the data that describe a certain problem that a person or group is facing. Taking that description and generate "how might we" statements that each deal with an aspect of your description.

Expectation outcomes:

The process of determining a unique human-centered problem from a large, unorganized set of information.

Process 3. Ideate

Before teamwork: Students have a defined problem: user, need and insight. They have multiple brainstorming prompts "how might we" to brainstorming off. Educators might want to combine groups to have 5-7 students brainstorming in a group.

During teamwork: Students have high degree of participation, are following the brainstorming rules (especially being visual and deferring judgment), and are listening to each other and building on each other's ideas. When the degree of participation of student groups get low, encouraging the group to

move on to a new prompt or to do a warm-up improve activity to get performance up.

After teamwork: Students (as a group) have selected around 5 ideas to move forward by voting.

Expectation outcomes:

The value and benefit of following the brainstorming rules: being visual, building on other's ideas, deferring judgment on ideas.

Process 4. Build/Prototype

Before teamwork: Students have a variety of ideas to select from and move forward on.

During teamwork: Students have access to prototyping materials. Students should build prototypes as soon as possible so they are easy to change their ideas.

After teamwork: Students should have multiple prototypes then they are ready to test and a clear idea of what they are testing, how will they record and incorporate feedback?

Expectation outcomes:

- The value of building to think (Bias towards action).
- The importance of rapid prototyping.

Process 5. Test

Before teamwork: Students have multiple prototypes that they are ready to test a clear idea of what they are testing, how will they record and absorb feedback.

During teamwork: Students should take good notes and ask to follow up questions on feedback received from users. Students should set up more than 3 testing presentations for feedback from users.

After teamwork: Students have a number of ideas of how to move forward and create a new prototype.

Expectation outcomes:

- Show the meaningful value by building a clear prototype and then test an idea.
- How to incorporate feedback and interaction.

Following this process, in the classroom, design thinking pedagogy encourages educators to release the narrow, rigid process of traditional learning and capitalize on the learner-centered principles of connection-making, inquiry, and self-directed learning. In such an environment, integration is essential (Marshall, 2005) as students construct knowledge through inquiry, doing to learn, making mistakes, and becoming more self-directed.

A learner-centered teacher is one who makes the shift from content delivery and nice end products to building student capacity, co-creating learning goals, and a focus on making the learning process the primary focus.

4.2 Tools of design thinking in each process

Process 1. Empathy

Tool①: 5 Whys

Tool to deepen understanding of an issue.

Teams have an interview with involved members in which they ask 5 consequent "Why?" questions.

Questions are directly related to each other, and every further question goes deeper towards the root of the problem.

Tool②: Customer's Shoes

Tool to explore and experience the lives of customers from first-hand perspective.

Team members display themselves to real -world situations and activities. They follow and note down their personal feeling, emotions, and thoughts throughout the process. Teams develop a deep empathetic feeling towards design and future customers, gains valuable and meaningful data, and gathers contextual insight into the customer's world.

Tool③: Interview

Tool to get information and gain insights.

Team members meet with individuals and groups that are involved in design problem as stakeholders or experts and ask a series of questions to gain insights. Team members prefer contextual interviews that happen in the environment of future use or daily environment of the interviewer. Contextual interviews relax the participant, help them to retain and give details as well as help the designers to understand the spatial context (Stickdorn & Schneider, 2010).

Process 2. Identify/Define

Tool①: Butterfly Test

Tool to select the most interesting, appealing and relevant ideas and concepts.

Concepts and/or their visualizations are put on a wall; every participant has a certain amount of votes that he places on the most attractive concepts. The concept with most votes wins.

Tool②: Brainstorming

Tool to generate ideas as many as possible.

During a set amount of time people give all ideas they can come up with. The goal of this session is to come up with as many ideas as possible in a real business environment.

Process 3. Ideate

Tool①: Business Model Canvas

Tool to describe, analyze and develop business models for concepts.

Teams in collaboration with members creates a document that analyze all aspects of the business. This document clarifies the core aims and priorities and identifies strengths, weaknesses, opportunities, and threats

Process 4. Build/Prototype

Tool①: Build Real Prototypes

Creating multiple iterations to enhance the functionality and patient-centered focus.

- Utilizing Android/ios-based tablet and smartphone that provided a large lightweight patient display and compact nursing interface.
- Fixing bugs that presented in early testing and real-world settings.

Process 5. Test

Tool①: Assumption Testing

Tool to test assumptions of teams about the concept.

Teams establish assumptions about the idea or concept and plans how to test them in the most efficient and most effective way. Main aspects to be tested are the possibility for value creation, the possibility of execution, the difficulty of adaptation, scalability, how justifiable it is.

Tool②: Learning Launch

Tool to test a product or service on a small scale.

Teams launch product or service in a small scale of customers to test it. The key idea is tested in the real marketplace with real customers. Teams gather reliable real-world feedback that help to learn about the idea and improve it.

Tool③: "WOW" Zone Testing

Tool to check the stability and feasible of an idea or a concept.

Teams tests the idea or concept for three parameters. Firstly, teams check if customers have a desire to obtain or interact with the idea. Secondly, teams should check if the company is able to execute the idea. Thirdly, team need to check if the idea is financially reliable. If the idea fits all three constraints, it is developed further; if the idea does not fit all three points, it is reworked until it fits.

5. Conclusion

The purpose of this paper was to analyze and understand what benefits implementing a design thinking approach (combined with the traditional teaching and learning practices) can bring in fostering creativity and the culture of innovation in the Japanese university education. Kelley and Kelley (2013) described creative confidence as the belief in one's ability to create change in the world. Creative confidence is the ability to come up with new ideas and the courage to try them out. It is built upon generating new approaches and solutions.

Meanwhile, according to Lawson (2006) highlighted the fact that designers use episodic knowledge more than procedural knowledge. Following from this, more attention needs to be given to the fostering of design thinking skills within an educational context and strategies for education need to be considered and devised. Since knowledge and research of design thinking are inextricably linked to practice, researches aimed at improving design the education and practice of design thinking may need to be grounded in a deep understanding of the nature of design methodologies.

Thus, embracing the human-centered and prototyping mindsets impacted how the university curriculum was designed, how the university mentors interacted with the university students, how the university students interacted with the university mentors. Students need to feel empowered and supported to go outside of the higher education environment to talk to potential end users.

In a conclusion, the goal of design thinking education is to foster and nurture students to a human-centered attitude as well as a deep-rooted understanding and mastery of a set of discrete skills in design thinking and making. The human-centered design thinking in general should be an integral part of the higher education curriculum for any design-oriented degree right from the start.

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