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Impromptu Reflection as a Means for Self-Assessment of Design Thinking Skills

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Introduction

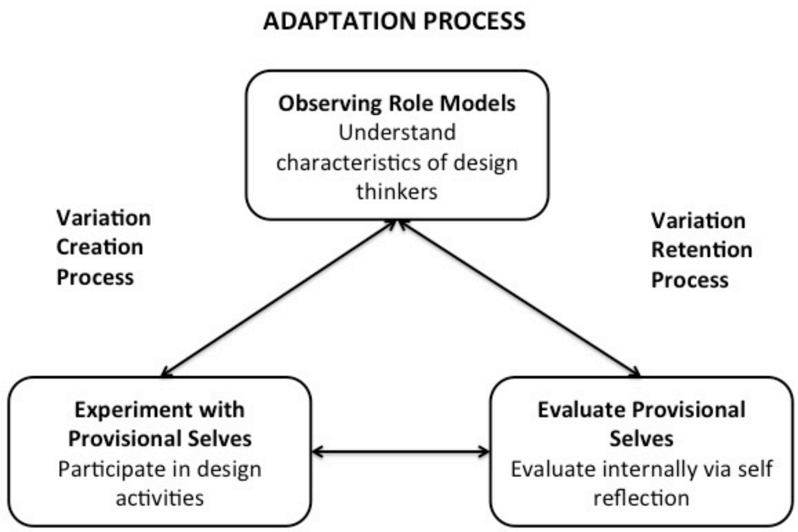
This paper serves as a preliminary inquiry into understanding how engaging in reflective practice can serve as a means of self-assessment for design thinking skills. The encouragement for this work lies in the individualistic nature of design thinking skills. Another perspective that we bring to this inquiry is that of our research interest in Makerspaces and understanding how learning and its subsequent assessment can take place in such informal learning environments.

Design thinking has been articulated in many different forms. Dym et al.[1] identified the following approaches to characterize design thinking: "design thinking as divergent-convergent questioning, thinking about design systems, making design decisions, design thinking in a team environment, and language of engineering design". According to Brown [2], some characteristics of the profile of a design thinker include "empathy, integrative thinking, optimism, experimentalism and collaboration". The commonality between these approaches and aspects is that design skills are understood and experienced by different individuals differently. This may be attributed to the context of the design activities, prior knowledge of the learner, personally meaningful connections, and other humanistic factors.

In this paper, we first situate the study in existing literature, and then present the philosophical and theoretical frameworks that inform this work. We employ a narrative analysis approach to investigate how students reflect on their design experiences. We further map these reflections to theorized aspects of design thinking in order to understand how well students can reflect on their design thinking skills. The narratives reported here were collected at a summer camp for middle school students. This understanding of students' abilities to reflect upon their design thinking skills further paves the way for a model of self-assessment of design thinking skills.

Theoretical framework

We employ Ibarra's theory of provisional selves[3] to understand how learners proceed through developing design thinking skills. According to Ibarra, individuals experiment with "provisional selves" to accept and internalize them. The three basic tasks in this adaptation process, are ": 1) observing role models to identify potential identities, 2) experimenting with provisional selves, and 3) evaluating these experiments against internal standards and external feedback" (p. 1). In this study, middle school students were initiated into ideas pertaining to design thinking via formalized instruction at a summer camp. The learners then engaged with design activities as they experimented with their provisional selves, and then they were asked to reflect upon their project. These reflective narratives that form the third task of Ibarra's theory constitute the data for our narrative analysis. It is important to acknowledge that the instruction that the students received and the prompts for self reflection were not driven by Ibarra's theory (viz., our analysis invoked this theory which has previously been used in the context of professional identity development).



Adapted from: Ibarra, H. (1999). Provisional selves: Experimenting with image and identity in professional adaptation. *Administrative Science Quarterly*, *44*(4), 764–791.

Philosophical framework

Our philosophical framework that encourages this work is informed by a humanist paradigm. We believe in the individual nature of learning and development and that humans utilize their self agency to achieve goals personally meaningful to them. A recent work with the running theme of looking at engineering as an enterprise for people, with people, and as people [4] represent our ideological underpinnings. Other work that is a manifestation of our ideology makes a case for an interest-based framework for engineering challenges in K-12 classrooms [5], broadening contexts of engineering challenges to broaden participation in engineering[6], and the implementation of classroom Makerspaces to make individualized learning in such spaces holistic[7].

Literature Review

The maker movement has spread itself to myriad places like K-12 classrooms, community spaces, libraries, museums, and other DIY hobby places. Different Makerspaces take different shapes according to the equipment they house, the social setting of the space and other human factors such as the interests and attitudes of the people who work in the space [8]. We believe that this human side of Makerspaces presents an opportunity for inquiry into individualized learning models, as clearly the humanistic nature of this space does not permit a one-size-fits-all solution.

Maker Ed was launched in 2012 with the aim of “developing a maker network of institutions, youth serving organizations, statewide afterschool networks, corporations, foundations, and makers seeking to accelerate and deepen the Maker Movement" [9]. Many libraries and museums such as the Children's Museum of Pittsburgh, New York Hall of Science, Chattanooga Library, Maker Lab at Chicago's Harold Washington Library have also been propagating Makerspaces as educational spaces[10]. The emphasis however in most of these initiatives is directed towards participants making things under the assumption of implicit learning.

There has been little to no work done to understand how learners learn in Makerspaces, and to find or develop tools to assess this learning. In the recent ASEE conference Morocz et al. [11] presented plans of measuring the impacts of a university makerspace "through engineering design self-efficacy, retention in the engineering major; and idea generation ability".

A study by the Maker Ed Open Portfolio Project [12] strengthens the promise of our proposal to employ self-reflection to assess learning in Makerspaces. This work presents self-reported data by Makerspaces all over the United States about their alignment with national educational initiatives. Most sites reported themselves as being aligned with STEM (94%) (Science, technology, engineering, and mathematics), STEAM (89%) (STEM + Arts), and technology education (79%). Approximately half of the sites also reported employing NGSS Science and Engineering Practices (NGSS Lead States, 2013), such as defining problems to investigate (48.9%), planning and carrying out investigations (44.7%), and designing solutions to a specified problem or task (44.7%), multiple times a week. However only 36.2% of the sites reported engaging in argument from evidence 1-2 times per month. Thus the learning and skill development in Makerspaces might be going unacknowledged.

Makerspaces present themselves as great environments for development of design thinking as the associated humanistic nature coaxes engagement at an individual level i.e. different people will develop different aspects of design thinking differently in Makerspaces.

Design thinking skills

For the purpose of this study, we map narratives from our participants to aspects of the profile of a design thinker as put forth by Brown[2], and three chosen dimensions of the Informed Design Matrix by Crismond and Adams[13]. Following is a brief on these aspects.

Brown[2] writes about empathy as a skill that arms design thinkers to consider multiple perspectives while designing, and employing a people first approach. This is governed by observing the world around them in great detail.
Integrative thinking is an aspect of design thinkers' profile that make them look at problems in a holistic way, irrespective of whether the new information gathered bolsters or contradicts what they already know. Further still, they look past constraints and believe in the existence of alternate solutions that can better already existing ones, thus exemplifying optimism. Brown further champions the idea of being creative as opposed to a single tracked and incremental way of solving problems. He calls this aspect experimentalism. Lastly, he challenges the concept of a "lone creative genius" (p. 3). Design thinkers work in collaboration with people from different expertise, and many times are experts in more than one field themselves.

Our three chosen dimensions from the Informed Design Teaching and Learning Matrix[13] are as follows:

Problem solving vs. Problem framing

Problem solving vs. problem framing informs the way beginning and informed designers understand the design challenges that they are presented with. It is claimed that beginning designers believe that "understanding the design challenge is straightforward" (p. 747). Which makes them formulate solutions much sooner, as compared to informed designers, and also perceive the problem as straightforward and well structured. On the other hand, informed designers are claimed to "understand the challenge as best they can, but then delay making design decisions" (p. 747). As compared to beginning designers, their focus lies on framing the problem well as initiated by an in-depth understanding of the challenge itself. Some of the evidence for self-reflection include (1) how soon a solution was thought of, (2) their deliberations and understanding of the need and criteria, (3) resources exhausted in the problem scoping process, (4) simplification of the need/problem, and (5) Iterations that were engaged in for problem formulation and scoping.

Unfocused vs. Diagnostic Troubleshooting

Unfocused vs. diagnostic troubleshooting renders an understanding of the strategies that designers employ to troubleshoot while designing. Beginning designers are claimed to have a "non-analytical way of viewing the plans and performance tests" (p. 766). They do not necessarily focus on problematic areas of their design but rather pick areas to solve problems in with little to no deliberation. Whereas, informed designers anticipate where problems may occur and "focus their attention on [these] problematic areas of their potential solutions and products" (p. 766). Whilst doing this, they effectively diagnose the potential problems with their design solution. Some of the evidence for self-reflection include (1) deliberations on performance measures, (2) abandonment of ideas and solutions, (3) foreseeing functionality of the prototype, (4) trials with multiple cases of simulations, and (5) narrowing focus on present and potential problems.

Haphazard or linear vs. managed & iterative designing

Lastly, haphazard or linear vs. managed & iterative designing looks into how designers revise and iterate while designing. Where beginning designers are claimed to design in either haphazard or linear ways, informed designers employ an "iterative process, while improving ideas and prototypes based on feedback and cycling back (p. 769)". This is a transition between working on aspects of design at random or following a laid down linear progression, to being more strategic in employing design strategies iteratively in a beneficial way. Some of the evidence for self reflection include (1) foresightedness in planning strategies, (2) incorporations of new insights through the process, (3) instances of checking their work and making changes, and (4) embarking on steps that appear risky.

Methodology

We employ narrative analysis to analyze our data qualitatively because (1) the data collected follows a logical sequence of events, (2) our data is purely verbal, and (3) the participants report on their personal experiences. Reissman[14] makes a case for narrative data following an order of sequence and consequence, which is then followed by making connections so that it is meaningful for a particular audience. Franzoi[15] also makes a similar claim by characterizing a narrative as the culmination of a story and chronologically successive events. Smith[14] makes the distinction between content and narrative analysis on the basis of the nature of the data analyzed; where content analysis looks at verbal and non-verbal data, narrative analysis takes into account only verbal data. He also makes a case for such verbal data to be indicative of personal experiences of the participants. Thus our study uses participants' narratives as qualitative data.

All participants were part of a summer camp for middle school students. Initially, they were acquainted with the process of engineering design via instruction by the research team. They then worked on a design project in teams of mostly four as they experimented with their provisional selves as design thinkers. The participants worked with children of ages 8-9 as their clients, and they were asked to make a game in consultation with them. Once the participants had come up with initial ideas for their projects, they interacted with their clients to get feedback from them. The clients then also came in on the final day of testing. On this final day, we the research team asked the participants general questions about their engagement with the project. These questions included but were not limited to: Does your project speak of your interests? What were the most challenging/hard parts of this project? What made you come up with this idea? What were you attempting to solve? If you could go back and change something, what would it be? The narratives were then collected as they evaluated their provisional selves via self-reflection.

Findings and Discussion

Below are excerpts from the student narratives collected that provide evidence of self reflection pertaining to the profile of a design thinker[2] and dimensions of the Informed Design Teaching and Learning Matrix[13].

Empathy

On their design serving their own interests well:
Student A: "But for the most part you have to leave them out because you can't be biased as to what the kids want."
Student B: "You have to make a product that the people actually want"
Student A: "You have to [inaudible] and actually listen to what they have to say"

Integrative thinking

While talking about a launcher (which was a part of their design) as a challenge:
Student A: "Some of the parts didn't come out right and it did come out really small, and we had to help them. This was the big part."
Student B: "It's a little bit smaller. It's kind of difficult to use, but once you actually get it like loaded, you can actually win the game in one shot. Maybe if we had something with less power or a smaller projectile that would not be able to knock all of them down at once. It would also be easier to use, easier to you know play around with."

Optimism
About how they decided on their solution:
“We all knew this game on the iphone called Trivia crack. It’s a game that asks you different questions on lots of different topics, and we thought we could revolutionize it in our own way.”

Experimentalism
On what they would change:
“I would upsize the target. It was a little hard for the kids to hit it, and maybe a different ball. The ping pong ball, it just bounced around.”

Collaboration
On their experiences of working together:
Student A: “You know designing it was …[inaudible] but it wasn’t something easy”
Student B: “Yeah, we had enough resources, so it wasn’t that hard”
Student C: “Coming up with this was a little bit difficult. Just getting it to work right. We still have some things we need to work on. We 3D printed this.”

As an ending statement:
“We got it finished, it looks nice, the kids love it, the adults love it. It was amazing, we did a great job.”

Revision and iteration – Managed and iterative design
On their solution
“What was interesting was like how long and how many times we had to modify our project to get it the right way. We had many different versions of what it was gonna be, and this is what it turned out to be, and I’m rally happy with it.”

Troubleshooting while designing – Diagnostic troubleshooting
On what they would change:
Student A: “For the most part we think with our trivia questions, they are kind of limited in age group that we have them tailored for. They are more for younger kids.”
Student B: “Mostly if we could have had a notch back because it was difficult for the kids to shoot, and load at the same time.”

Understanding the design challenge – Problem framing
While talking about the problem they worked on:
Student A: “Something like a game [inaudible] that would interest 8 to 18 year olds”
Researcher: “So that was your problem statement?”
Students A and B: “Yeah.”

The following quote presents critical evidence for an individual’s capacity to evaluate him/herself after experimenting with a provisional self. When asked if working on the activity had changed their idea of engineering, a participant responded:
“I don’t think it’s changed so much, but I have like a better idea of like what it actually is, and be able to understand it.”

In the preceding quotes, participants exemplified many of the aspects associated with design thinking. The participant exemplified empathy by taking into consideration what the kids (their client) want. By working through the constraints that spanned design, fabrication and implementation, the participant employed integrative thinking. The team had an optimistic shared belief of revolutionizing the existing game of Trivia Crack. The participant employed experimentalism in coming up with creative solutions pertaining to the size of their target and the ball they used to hit it with. The dialogue between two teammates of whom one called the project hard, and the other chimed in by saying that they had enough resources, and the other quote from the participant who commended everyone for doing a great job and reported their success in excitement, show collaboration. One of the participants reported on their managed and iterative process by talking about the different versions of their solution. The participants practiced diagnostic troubleshooting by focusing on the exact troublesome aspects of their project i.e. the trivia questions' relevance to their clients' age. Further still, they framed their problem well by reporting their exact problem to begin with, and neither jumping to solutions nor giving examples of potential solutions.

Conclusion

The merits of this study include, but are not limited to: (1) understanding the opportunities that Makerspaces present for the development of design thinking skills, (2) designing an individualized model for learning and assessment in Makerspaces, and (3) invoking social and self awareness to accentuate learning and assessment.

Thus, by this narrative analysis we make a case for reflection as a worthy practice for learners to self-assess their design thinking skills. We do so by invoking prior literature and presenting findings from students' impromptu reflections after working on a design project. As Makerspaces and similar environments make it in the limelight for educational purposes, it becomes imperative to conduct studies to fill the gap between what is practiced and the subsequent claimed educational benefits. By presenting our work in this paper, we posit one way of narrowing this gap.

Limitations and future work

The findings reported in this work are limited to excerpts from students' reflections on a particular design activity. Since all the students experienced a similar learning environment, and belonged to the same age group, further work spanning age groups, activities and settings, may help consolidate our results.
We adopted a qualitative inquiry approach focusing on narratives from the students, given the encouragement and scope of the research study. Having made a case for reflection in self-assessment of design thinking skills, our study also paves the way for future larger scale qualitative and quantitative studies, depending on the setting and research questions.

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