DESIGN THINKING AND METACOGNITIVE REFLECTIVE SCAFFOLDS: A GRAPHIC DESIGN-INDUSTRIAL DESIGN TRANSFER CASE STUDY

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ABSTRACT

Scaffolding is crucial as transfer of learning does not occur naturally and teaching-learning strategies found to be effective for experts may not be suitably adopted as is for novice learners. Furthermore, opportunities are often "found" or "made." The quality of solutions, however, is mediated by different conceptualizations of contexts. We aim to investigate whether design thinking and metacognitive reflective scaffolds can help graphic design students to design on a different canvas, i.e., for industrial design, in order to increase their job opportunities. Findings indicate that students are able to identify and match patterns, theorize based on their graphic design knowledge (to transform fuzzy association patterns into fuzzy associative rules) and analyse existing designs in the market to create their own designs. The significance of the study are useful to the learning of Science, Technology, Engineering and Mathematics, co-design of designs/uses for smart technologies, industrial design, and embedded cognitive systems, such as robotics and Internet of Things (IoT).

KEYWORDS

Conceptualization; design thinking; metacognitive reflective scaffolding; creative thinking; graphic design-industrial design; acquisition of expertise; transfer of learning

1. INTRODUCTION

Economies are increasingly knowledge-based, i.e., driven by knowledge, information and technology. Hence, the development of skills throughout life becomes critical. A McKinsey report on Education to Employment, highlights two critical issues in the 21st century: high youth unemployment rates and shortage of workforce with critical job skills, due to a mismatch in skills. For example, in 2013, 73.4 million young people are unemployed. In addition, 58% of employers surveyed think that entry-level new hires do not have the necessary skills. Consequently, in a dynamically changing and interconnected world, how can we best equip our students to cope with continuous changes, and to learn continuously?

UNESCO (2015) thus highlights the need for educational innovations, aimed at:

1. developing educational and training contents, pedagogies and knowledge to improve 21st century skills;
2. inculcating significant changes in values, mindsets, practices, behaviours and skills for now and in the future; and
3. promoting and translating principles of lifelong learning in skills development.

These aims focus not only on effective re-skilling and adjustment to skills mismatch (first objective), but also to the development of dispositions which would contribute to productive and sustainable development (second and third objectives). Subsequently, three sets of skills have been identified: (i) foundation skills, (ii) specialized skills and (iii) transversal/transfer skills. UNESCO further points out that these three sets of skills are equally important if we want to enhance the potential of education and the human innovative spirit to address authentic pressing issues facing our world today. These skills are also supported by Outcome-based Education (OBE).

1.1 Objectives

With the above scenario as background to our study, we investigate whether design thinking can help graphic design students to more effectively build knowledge, develop creativity and subsequently, design on a different canvas, i.e., for industrial design. We choose industrial design because of the similarity between the two disciplines. Industrial design mainly focuses on function and form, and is concerned with aesthetics, psychology, market analysis, user interface design and information design, ultimately, leading to interaction design (Pulos, 1988). Given our sample students' knowledge and experience with packaging design, we are interested to investigate whether this knowledge can be transferred to industrial design.

1.2 Hypotheses

Studies by Papert (1980) and many other learning sciences research, attest that computers are construction tools, with great capacity in expanding what people can create and what they can learn in the process. Their constructionist research provide evidential indications that many of our best learning experiences are when we are engaged in designing and creating things, particularly things which are meaningful either to us or to others around us. Bereiter (1995) contends that learning dispositions and beliefs are key in determining learning outcomes.

Subsequently, based on their arguments, we contend that knowledge construction and consequently, learning outcomes (OBE, 1994) and transfer, are built on students' dispositions. We have scaffolded the development of such dispositions through design thinking, framing and metacognitive reflection in our studies (Lee & Wong, 2013, Lee & Wong, 2014a, Lee & Wong, 2014b). Though the first study involves low-fidelity prototyping and the subsequent ones high fidelity prototyping, findings are consistently positive. This leads us to our first hypothesis.

Hypothesis 1: If students fully practice design thinking, and apply our metacognitive reflective scaffolds, they may be able to better link between theory and practice.

This study is different from our prior studies due to the domain concerned, i.e., graphic design. In this study, we incorporate Art and Design theories as methodology. We regard Communication theory as primary in design. Initially perceived as a linear process (Shannon & Weaver, 1949), Schramm's (1971) Communication theory involves sending messages and correspondingly providing and interpreting feedback. User experience is important in determining the quality or success of communication. The emphasis on fields of experience between the sender and receiver implies that life experiences enhance the quality of communication when they overlap. This leads us to our second hypothesis.

Hypothesis 2: If students are able to create user experiences based on Communication theory and related theories, they should be able to design more creative industrial designs.

Our research model is illustrated in Figure 1.

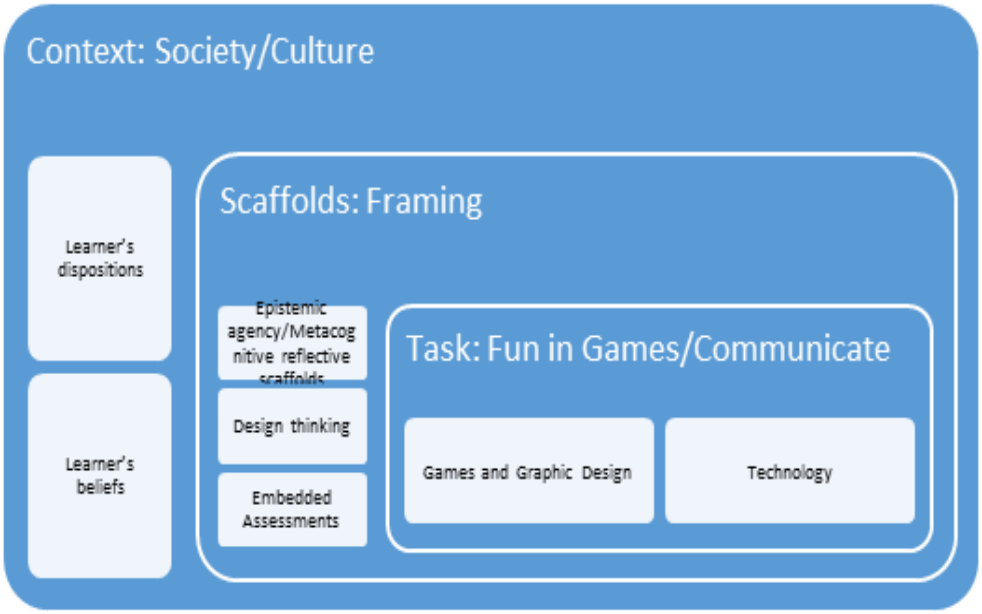

Figure 1. Research model for this study

1.3 Significance of the Study

First, Verganti (2008) argues that innovation is often through increasing the emotional and symbolic value of products. However, the underlying mechanisms are still poorly understood. Second, we hope to increase cognitive access, i.e., equal opportunity to understand and learn, regardless of ability, race, ethnicity, socioeconomic status, and gender as espoused by Outcome-Based Education (OBE, 1994) by developing epistemic agency (Scardamalia & Bereiter, 1995) through our design scaffolds Third, we argue that smart communities encompass not only the use of smart technologies but also the co-design of designs/uses for these smart technologies. In line with natural computation, this implies a symbiotic relationship between the built environment and its ecosystems. A greater awareness of this symbiosis may be useful industries such as industrial design, and embedded cognitive systems, such as robotics and Internet of Things (IoT), due to the translation of epistemic agency to autonomicity in software agents.

2. RELATED WORK

Consistent with the nature of problem-solving in authentic environments, an experimental game-thinking approach which captures the "fuzzy" characteristic of ideation/ innovation contextualized within the ecosystem(s) is adopted throughout our study. The following sections explain why.

2.1 Socio-Cognitive Framework and Framing

One of the approaches directly related to the theory of constructivist learning, experiential learning (Papert, 1980; Bereiter, 1995) espouses that learning is constructed as a response to each individual's experiences and prior knowledge (sense-making); i.e., that learning occurs through active exploration (learning-by-doing) within a social context.

Following from this, we contextualize the design challenge within Engle's (2006) sociological framework. Her framework espouses the constructivist-constructionist views, where technology and learning communities are key mediators which improve sense-making and user experience between interconnected contexts. Given that design is a communicative process, the sociological framework provides a more holistic context within which learning can be framed.

We choose this framework because it provides a situative theory of transfer whereby interconnected contexts create a coherent framework within which students can generatively use what they have learnt. Thus, the ability to frame accurately is crucial to epistemic agency as it provides the reason/ motivation/ epistemology for learning. In other words, if students comprehend and are able to relate to their personal goals, they are more likely to use the content-based supports more effectively. Hence, framing within a socio-cognitive framework will enable instructors and researchers to develop more comprehensive explanations underlying mechanisms of transfer. Transfer is scaffolded/facilitated because as Neumier (2013) points out, the external perspective affords the development of a metaposition and the development of metaheuristics.

2.2 Design Thinking

Design thinking is interdisciplinary and focuses on context, empathy and user experience (Brown & Wyatt, 2010). Grounded on inquiry-based learning, Dunne & Martin (2006) recommend design thinking because problems are framed, questions are asked, ideas are generated, and answers are obtained. These are carried out iteratively, Figure 2 illustrates the design thinking processes. More importantly, being user-centred, outcomes are emergent. As such, the design thinking process allows not only information and ideas to be organized and choices to be made typical of problem-solving, but also insights to be gleaned, situations to be improved, and non-prescriptive/didactic knowledge to be developed.

We choose design thinking because it best captures the game-like experimental spirit and balancing of multiple decision criteria inherent in game design and game-based learning. Furthermore, our prior studies (Lee & Wong, 2013; Lee & Wong, 2014a, Lee & Wong, 2014b) with inquiry learning (first study) and with design thinking (second and third studies) are successful in building knowledge and in developing creativity.

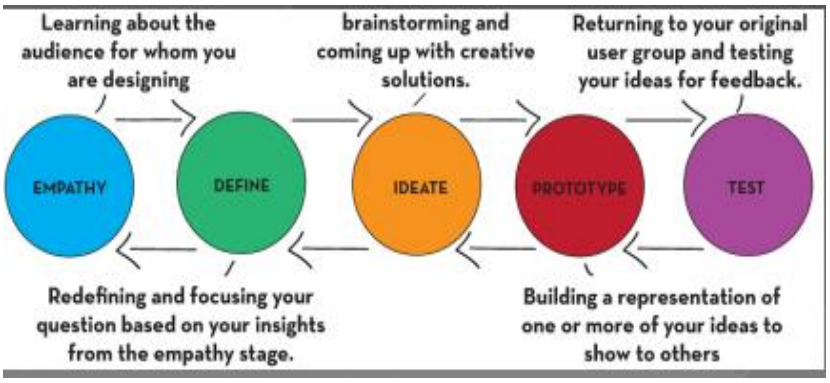

Figure 2. Design thinking phases

3. METHODOLOGY

3.1 Sample

Sampling is purposive. Our sample students are 16 graphic design undergraduate students in a private university in Malaysia undertaking the course Design Reflective Practice, a consequent course after Design Research. All of them are final year students. They are the population for the course. In both courses, design thinking is taught and applied as an addition to the syllabus; serving as the binding thread across course content. The students' backgrounds are mixed, from both Arts and Science (Engineering). Experimental duration is 13 weeks.

3.2 Procedure

Similar to our prior work, we design based on Marini and Genereux's (1995) context, task and assessment.

Context: We frame learning of research skills as increasing the possibilities of job opportunities. First, we ask students what they think industrial training would be like, employers' expectations of them, their designs/products and self-reflection on their own strengths and weaknesses. These form the primary means of framing. A secondary means of framing is through the design of the assessment. Subsequently, students are presented with multiple lectures on various Art and Design movements and theories and have experimented with these ideas as in-class projects.

Task: Thus far, their in-class tasks have been to produce digital media Art to communicate. For the two hour lesson near the end of the course, the objective is to gauge how much they have learnt from the earlier lessons. It functions as one of the embedded assessments in the course. Students are asked to discuss what and how they would design a wallet for their loved ones and why. This is based on an example on design thinking by Stanford University's d.school. Subsequently, they are given the task of designing a wallet for the high-end market (a different target market from the example) where money is not a concern. They are allowed to incorporate technology if they deem suitable. Feasibility is not the primary concern as technology can be developed if the idea is marketable.

Assessment: Their end-of-course final assignment is based on the use of theories. The assessment criteria are similar throughout their reflective practice exercises and assignments. In this study, we regard fun and interactivity as contributing to sustainable user experience. As such, students are evaluated mainly based on fun, interactivity and sustainability. The assessment rubric used was refined from our prior studies (Lee & Wong, 2013; Lee & Wong, 2014a, Lee & Wong, 2014b). It is as shown in Table 1.

Table 1. Refined assessment rubric

	A	B	C	D
Fun	Users are addicted/ intrinsically motivated	Users find it fun and don't mind spending 2-3 hours per day at the Website/ application.	Users find it somewhat fun but wouldn't want to go to the Website or use the application unless they have to.	Users find it boring and dread to go to the Website or use the application.
Interactivity	Users are actively creating and/or co-creating objects and interactions which will result in higher quality objects and more meaningful interaction.	Users are creating and/or co-creating objects and interactions and the outcome are more objects and more interactions which are beautiful to them.	Users are creating and/or co-creating objects and interactions.	Users are not creating and/or co-creating objects and interactions.
Sustainability	Three to four dimensions of application.	Two to three dimensions of application.	One dimension of application.	Failure to sustain.
Problem-solving	Problem and hypotheses properly formulated across 2-3 domains.	Problem and hypotheses properly formulated across 2 domains.	Problem and hypotheses properly formulated across 1 domains.	Problem and hypotheses improperly formulated.
Significance/ contribution	Outcome can actually be used in society directly.	Outcome needs to be adapted slightly before it can be used in society.	Outcome needs major revision but can be adapted before it can be used in society.	Outcome is purely adoption of an existing solution.
Novelty	The outcome is original in relation to the existing work locally and internationally.	The outcome is original in relation to the existing work locally.	The outcome is original in relation to the existing work in the local community.	The outcome is not original.

4. FINDINGS

All students incorporate technology and whatever they perceive as being hot and uptrend in the market in order to optimize user experience and perception of classiness leading towards perception of the brand. All designs indicate top concerns with regards to security followed by customization to individual style. The differences in their designs lie in their emphases on what they perceive as the customers' needs, preferences and desired user experience. In addition, Group 1's design is more inventive and multi-dimensionally functional whereas Group 2's design is functionally adaptive and Group 3's design focuses more on style than functions. Examples of their designs are presented below:

Group 1: Sensor/face detection-unlock function, touch-screen ordering function (the chosen button will eject the card which they want to use so users do not have to rummage through their wallets), charging by shaking (movement detection) so no need to worry about charging anywhere anytime (even while walking), colour change, water proof, light-weight and GPS in case lost.

Group 2: Finger/palm print recognition, the wallet is digitalized totally, functionally similar to a laptop in the sense of both sides of the wallet being able to swivel on different planes in any desired position and the screen being electronic so that all necessary items (assuming that these items are also digital as is possible in the future including ID and cash), magnetic open/close flap, USB port at the bottom left, and a cover which can change based on nanotechnology, GPS in case lost.

Group 3: Thumb print recognition in order to unlock, changeable illustration with black background for day and white background for night.

Each group has targeted only one perceived market. However, considering the beauty and desirability, of each design outcome, we contend that the diversity in design outcomes is able to reach wider and more diverse markets for an organization.

5. CONCLUSION

The discovery of knowledge is usually fuzzy and hence, it makes sense to base knowledge discovery on what is known, i.e., on pattern recognition and subsequently, hypothesize, experiment and consequently, formulate new patterns/ principles/ generalizations (defuzzification).

Fuzziness during knowledge discovery is natural and even encouraged due to the advantages and possibilities of emergent outcomes from such experiments. We hope that based on our design factors (constructionism, design thinking and metacognitive reflective scaffolding as embedded assessment) and findings, cognitive access will improve despite our limited cognitive processing capabilities. Subsequently, with the increase in application of eclectic interdisciplinary student-centred approaches, we hope that students will be able to become better conceptualizers and designers; able to develop and sustain the ability to apply and synthesize knowledge learnt to create practical, useful new knowledge through interactions with the learners' local and international communities and that these designs will become more effective, efficient and most importantly, fun, generative and, meaningful.

The next question is can we accept and find new ways to encourage more meaningful experimentations in the Sciences, where logic is more dominant and knowledge and representations are more well-structured? How can we make learning more fun, interactive and sustainable in the Sciences and increase the number of students taking up Science, Technology, Engineering, and Mathematics (STEM) and its variants in its applications to different domains e.g. e-commerce, social entrepreneurship, healthcare?

Our sample size is small and there may be extraneous variables. At this moment, we can only claim that design thinking and our metacognitive reflective scaffolds help students to be more aware of salient design factors that they need to consider to reach the perceived market and subsequently, to improve lifelong learning, i.e., epistemic agency resulting in meaningful and sustainable knowledge acquisition and knowledge building.

Future work involves broadening our framework to include wider considerations. We intend to include lessons from these two studies as well as studies from the creative industries towards enhancing STEM education and transfer of learning to meet the challenges of the 21st century. We will also include framing from an entrepreneurial perspective and an adapted LBD-based reflection grounded on our findings, to develop deeper understanding of design and design thinking towards more meaningful and sustainable social innovations.

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