Using Design Thinking to Create a New Education Paradigm for Elementary Level Children for Higher Student Engagement and Success

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Abstract

Can design education have a positive impact on primary school education beyond merely preparing designers? As designers, we know almost intuitively that design education is 'good education', and most designers would affirm that it would be beneficial to expose children to design education, because of the benefits of the signature pedagogies of design, such as problem-based learning, human centred creativity and iterations of prototyping and testing.

This paper seeks to review and synthesize existing literature and make preliminary analyses, which will support the development of design thinking education interventions at primary school level, which could lead to a paradigm shift in education at this level. While it has been widely demonstrated that design education can play a successful role in supporting traditional education models in the delivery of skills such as math and language arts, this paper seeks to demonstrate that in addition to meeting traditional education demands, design thinking principles in children's education, such as empathy, collaboration and facilitation, human-centeredness, and creativity by iterations of prototyping and testing, will provide a sound base for children not only seeking to enter a design profession in the future but moving into any profession in the future and will lead to higher engagement at school and greater success in life.

Key words

primary education, design thinking, design education, empathy, cognitive development

1. Introduction

In the introduction to the book "21st Century Skills – Learning for Life in Our Times", Trilling and Fadel challenge their audience to consider what learning would be like if it were designed for a future twenty years away, around skills that children would need to be successful in the future (Trilling and Fadel 2009). A study conducted with 400 hiring executives of major corporations highlighted seven basic and applied skills lacking in secondary and tertiary level graduates, which are described as the "twenty-first century gap" by Trilling and Fadel These lacking skills are: oral and written communication, critical thinking and problem-solving skills, professionalism and work ethic, teamwork and collaboration, working in diverse teams, applying technology, leadership and project management (Trilling and Fadel 2009).

These twenty-first century skills resemble learning outcomes from many design courses: "learning and innovation skills, critical thinking and problem solving, communications and collaboration skills and digital or ICT literacy". The desirable model for 21st century learning that Trilling and Fadel propose also seems to describe a design class with teams working together to solve problems, technology infused curricula, real-world challenges, project based learning and a focus on innovation and creativity (Trilling and Fadel 2009). It is evident in the literature that elementary, K-6 or primary level education (education for children aged approximately 5 – 11 years old) is 'ripe' for an overhaul. Traditional education was developed to prepare children for work in the Industrial age, but economies are now moving into the Knowledge Age (Trilling and Fadel 2009). Businesses and countries will require people who are able to play a role in building the knowledge economy and these people will be innovative, creative problem-solvers. It is the appropriate time to bring design methods and pedagogies into mainstream education to help lay a sound base for the development of innovative, problem solvers who will have the needed skills for the 21st century and beyond.

The aim of this paper is to highlight possibilities for a paradigmatic shift in elementary or primary-level education, also referred to as K-6, through a base on design process and design thinking. In this paper existing literature will be reviewed and synthesized to make preliminary analyses. However in this paper, the authors seek to demonstrate that design education provides a sound base for not only traditional academic education or for professionals who will go on to work in a design and knowledge-based industries, but more importantly that the skills imparted through design education such as problem solving skills like innovation, curiosity and critical thinking, and social skills of empathy, collaboration and facilitation, go beyond the specific knowledge-focused fields and lays a sound base for any career, therefore demonstrating how design thinking based education for children could be a very useful paradigm to be adopted.

2. 21st century skills and predictors of student success

While most children are excited about school in their early years, this excitement about learning falls off as they approach the end of primary school because a) learning stops being fun b) they begin to compare themselves with each other and c) because they begin to feel the impact of standardized testing (Levine 2012).

Literature on children's success indicates that children's future success in life is not predicted by their academic output. Other non-academic abilities are seen as greater indicators of children's success than academic outputs. Psychologist Madeline Levine (2012) identifies seven 'coping' skills, which are key for children's development:

- enthusiasm,

- Resourcefulness: Children who are resourceful can get themselves out of difficult situations and will try out different ways of coping to find the most efficient solution

- Creativity: Creativity encourages children to experiment and to approach problems in different ways

- A good work ethic: Levine notes that a good work ethic and academic engagement go together

- Self control: Self control is about developing and internalizing one's own rules, and being directed by one's good choices

- Self Esteem: Children with high self esteem perform better academically and socially.

- Self Efficacy: The belief that one plays a significant role in one's destiny and success, also described as 'agency' by psychologists

Levine laments that the academic system in the United States focuses on testing a limited range of skills – primarily Mathematics and English, and this focus on testing this limited range affects the development of critical thinking skills in the curriculum. (Levine 2012). The focus on academic success is in fact a significant contributor to emotional distress among American youth (Levine 2012), and the limited definition of success excludes many individuals who have the potential to be valuable contributors to society. Though she identifies the seven coping skills, throughout her book, Levine refers to many other important qualities that impact children's success. She highlights the importance of curiosity and asking questions. According to her, children's questions advance their critical thinking and creative abilities and asking the right questions leads to greatest possibilities for learning (Levine 2012). Levine encourages parents to value academic risk-taking, which means that children should focus more on questions than answers (Levine 2012). While most children can memorize information, curiosity, persistence and engagement are in fact the drivers of lifelong learning (Levine 2012). She notes that internal motivation is correlated with positive outcomes such as higher academic achievement and less emotional problems (Levine 2012). She notes the importance of empathy, which is a skill that has to be developed in children (Levin, 2012), and suggests that the explosion of bullying in elementary school is an indicator that society has not been successful in promoting empathy among children (Levine 2012).

Paul Tough, highlights some different qualities, that at times overlap with Levine's, that are vital to children's success. For Tough, the combination of strengths that are most likely to predict children's success are: 'grit', self-control, zest, social intelligence, gratitude, optimism and creativity (Tough 2013). In addition to the listed strengths, Tough in his book highlights the importance of motivation and volition, willpower, conscientiousness, which is in fact the trait that most predicted workplace success, character – or 'nice guy values', cognitive flexibility or the ability to visualize alternative solutions to problems and cognitive self-control or the ability to resist an instinctive response in favour of a less obvious solution (Tough 2013).

Psychologist, Carol Dweck, has developed a theory on student motivation that points to the differences between a growth mindset and a fixed mindset. For children with a growth mindset success is about stretching themselves and learning new knowledge, whereas for children with a fixed mindset, success is about proving that they are 'smart'. Failure in the fixed mindset is associated with stupidity and Dweck suggests this mindset, which is widely promoted at schools, can put an end to an interest in learning (Dweck 2006).   Students with the growth mindset welcome the challenge of learning that failure brings. Dweck acknowledges that her own change to a growth mindset resulted in her becoming more courageous and open and leading a richer life.

The designer and design educator would recognise that many of the attributes described by Levine and Tough, and even the growth mindset promoted by Dweck can and are in fact be reinforced in design education. While the contemporary interest in STEM education has led to much discussion on how exposure to design education, with its traditional constructivist base in art education, can play a great role in helping make abstract concepts such as science and math more concrete through the manipulation of materials and the act of making, and therefore improving academic performance, a greater benefit of exposure to design education, may in fact be the development of these non-academic qualities, which can perhaps play an even greater role in preparing students for their future success.

3. The evolving discipline of Design

Nigel Cross identifies design as a 'multifaceted cognitive skill' and a natural intelligence, akin to Gardner's multiple intelligences, which everyone has not just designers (Cross 2011). Howard Gardner's Theory of multiple intelligences proposes that we all have various levels of intelligence across a range of intellectual areas. These multiple intelligences allow learners to learn in different ways. The nine intelligences of Gardner's Theory are listed below:

Linguistic	**Logical/mathematical**	**Musical**
Spatial /visual	**Kinaesthetic**	**Interpersonal**
Intrapersonal	**Naturalistic**	**Existential**

(Pritchard 2013).

For Cross, 'design intelligence' involves 'deep reflective interaction' on problems and solutions, and the capacity of flexibility and the ability to switch between thinking and doing. (Cross 2011). In order to achieve this, designers have skills of 're-organizing' problems so that they can be interpreted differently, a process that he names 're-framing'; conducting research to find data, and analysing the problem data to create patterns which suggest possible solutions (Cross 2011). Cross stresses that though designers are admired for their solutions, it is really their skill in finding the right problems which separates 'good' design from mediocre or less acceptable design (Cross 2011).

Designers are able to find rich solutions from the complexity of the open, complex, networked and dynamic nature of contemporary problems, and as a result leading innovators are increasingly coming to this profession for help in addressing these complex problems (Dorst 2015). Kees Dorst describes today's problems as 'open, complex, dynamic and networked' and emphasizes that these

contemporary problems cannot be solved using conventional problem solving methodology, since new problems need radically different responses (Dorst 2015). He debunks some of the myths about design – that it is irrational, mysterious and just about creating beauty, demonstrating that design practices have 'matured into a real alternative to conventional problem solving strategies'. (Dorst 2015).

Deduction, induction and abduction are forms of reasoning. In deductive reasoning a conclusion is guaranteed while in inductive reasoning a conclusion is only merely likely. Designers often use abductive reasoning, which begins with incomplete information, which is used to form the most likely conclusion. Dorst differentiates between 'normal abductive reasoning' and 'design abductive reasoning'. He describes normal abduction with the following equation:

$$??? + HOW = outcomes$$

where the equation for design abduction is:

$$???+??? = outcomes$$

showing that in design abduction the 'how' is also questioned, and the two unknowns lead to creative innovation (Dorst 2015). In their process designers make unusual and interesting connections to create new 'whats' and 'hows' and test them during their iterative process. According to Dorst, the thinking across the design professions is fundamentally different to other professions that are based on deductive, inductive and normal abductive reasoning (Dorst 2015). The iterative process of design may in fact lead to Dweck's growth mindset since designers are encouraged to develop new solutions and test them many times throughout the process. The possibility of failure always exists in the design process, and when faced with 'failure', designers start the process over.

For psychologist Madeline Levine, the ability to ask good questions characterizes intelligence and creativity – much needed skills for the future envisioned by Trilling and Fadel. Dorst and Cross demonstrate that designers think in a way that is different to other professionals. Perhaps design-based primary education developed with a focus on curiosity, problem framing and re-framing and developing and asking the right questions could have significant implications on developing skills that have been identified as needed for 21st century success.

In the design process a 'frame' is a new way of seeing a problem situation, which results from design abduction (Dorst 2015). Designers go through the iterative process of examining the problem space (framing) and reanalysing and reframing the problem if the design solution they have developed is not satisfactory (Dorst 2015). Designers try to think through many solution possibilities before committing to developing one in detail.

4. Signature pedagogies in design

Signature pedagogies move the emphasis away from the content of a discipline, towards ways of knowing that are essential for the practice of that discipline (Shreeve 2015). In her chapter on 'Signature Pedagogies in Design', in 'Design Pedagogy', Alison Shreeve, describes the signature pedagogies of Design as the Studio, the Projects and the Brief, Materiality, Dialogue and the Critique (Shreeve 2015). The studio turns the focus of the class away from the tutor towards the student, creating a student-centred teaching approach (Shreeve 2015). Most design courses are taught through experiential methods that focus around a project or design brief. The design outcomes are open-ended which allows the student the space to be creative in developing a solution, which is unknown at the start of the project. Design students often also work autonomously in the development of these solutions. The role of the tutor according to Shreeve, is often to guide and advise rather than dictate, and both the student and the tutor have to tolerate great risk along the journey to a solution. (Shreeve 2015). 'Materiality' is fundamental to art and design education, which is based on 'doing and making'. The teaching and learning process in art and design education is 'dialogic', which is a feature of the student-focused approaches in design education. The dialogue does not only take place between the tutor and the student, but also peer to peer and in small groups (Shreeve 2015). Finally, the design critique provides an opportunity to agree on standards, to give feedback and to discuss alternatives, as well as to provide a model for the type of thought process that is needed by the design professional (Shreeve 2015). Shreeve identifies these pedagogies as ways to help students to act in ways that are 'professional and appropriate' (Shreeve 2015), but perhaps design pedagogies can also play a role in developing some of the cognitive and social skills that will lead to student engagement and success among students at elementary school.

Design processes

Robin Vande Zande defines a 6-step design process: "Define the Problem ➔ Investigate and research ➔ Generate Ideas ➔ Make the Prototype ➔ Present Solutions ➔ Evaluate and Revise" (Vande Zande et al 2014). She affirms that design educators can make a lasting impact on life and career skills for students by teaching them this process. Dorst describes design practices as developed around five general activities: formulating (understanding, identifying and framing) ➔ representing (externalizing, conversing and using multiple representations ➔ moving (creating primary generators, kinds of moving and moving the problem) ➔ evaluating (objective/subjective reflecting in action, judging on 3 qualities and suspending judgment) ➔ and finally managing (reflecting on action, briefing and pursuing parallel lines).

FORMULATING
UNDERSTANDING — IDENTIFYING — FRAMING

REPRESENTING
EXTERNALIZING — CONVERSING —
USING MULTIPLE REPRESENTATIONS

MOVING
CREATING PRIMARY GENERATORS —
KINDS OF MOVING — MOVING THE PROBLEM

EVALUATING
OBJECTIVE / SUBJECTIVE REFLECTING-IN-ACTION —
JUDGING ON 3 QUALITIES — SUSPENDING JUDGMENT

MANAGING
REFLECTING-ON-ACTION — BRIEFING —
PURSUING PARALLEL LINES

Figure 1. The spectrum of design activities (after Lawson and Dorst 2009). Source: Dorst 2015.

The Design Thinking process of Stanford's D School starts with 'empathize'. Key literature has identified that this is a skill that needs to be nurtured to ensure people's success and well being. The five steps of the D School's Design Thinking process are: "Empathize ➔ Design ➔ Ideate ➔ Prototype ➔ Test", while the five steps of the Design Thinking model promoted to educators by IDEO are: Discovery ➔ Interpretation ➔ Ideation ➔ Experimentation ➔ Evolution.
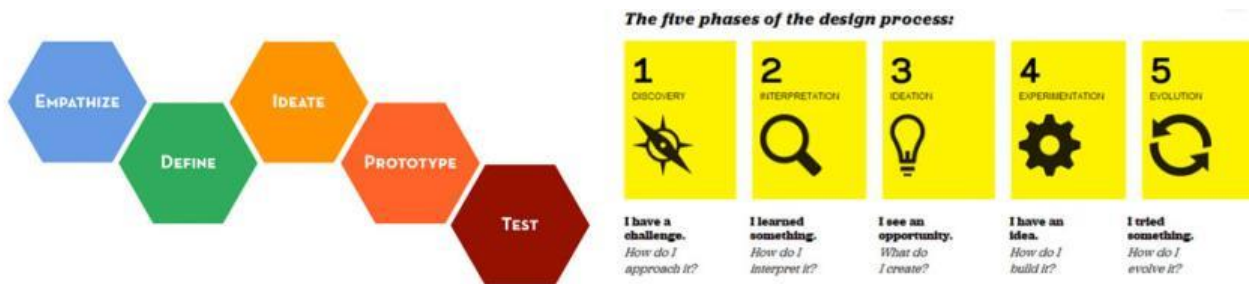

Figure 2. On the left the Design Thinking Process Stanford's D. School (Source: http://tinyurl.com/qedrujo) on the right, IDEO' s Design Thinking Process. Source: http://tinyurl.com/pv862hx

These four models promote curiosity, empathy, exploration of human and environmental needs through research, experimentation, critical thinking and a rigor that could lead to future success for all who are exposed to these process, not just design students by promoting 21st century skills and a growth mindset.

Yee and Jefferies point out that the key abilities of designers are the ability to empathize, visualize, synthesize and to resolve problems, and these skills are creating new roles and opportunities for designers (Yee and Jefferies 2013). In addition to developing more traditional core skills post-industrial design educators also have to nurture new skills such as facilitation, collaboration and empathy (Yee and Jefferies 2013) which are core to the Design Thinking Process, and are skills that match with the indicators for success for children. Collaboration is one key element of the design thinking process. Students in design benefit from collaborative problem solving, learning new skills from the teamwork that they must use in the process. In the group work they must focus on a goal, and this focus, created by the design thinking process, helps them to understand and practice the principles of collaboration, teamwork and empathy (Carroll, et al 2010). A new focus on facilitation, collaboration and empathy through Design Thinking could be a strong argument for making a case for signature pedagogies and processes from design education to be included in primary school education as a means of promoting 21st century skills in students that could lead to their greater success in the future.

Facilitation, collaboration and empathy, tie back to Paul Tough's indication that 'social intelligence' and 'character' or 'nice guy values' are tied to children's success. The skills of facilitation and collaboration demonstrate the ability to work with others. Empathy is a learned skill that is needed not just in design, but in many professions, and therefore empathetic children who grow into empathetic adults are likely to perform better in general and be more successful in life. There is a great body of literature related to empathy in diverse fields. In the medical profession, health care providers must be able to use cognitive empathy to understand the patient's point of view, as well as affective empathy to relate to their feelings (Chen et al, 2015). Empathy is required of physicians since it affects patient diagnoses and care. Patients will offer more information about their symptoms to empathetic physicians; and emotionally engaged physicians will attend more carefully to patients needs. Empathy on the part of the physician will also lead to greater patient satisfaction. (Stepien and Baernstein 2006). While most nursing schools use grade point averages GPA to ascertain who will be accepted into their programs, this data does not accurately predict who will become more empathetic nurses, and quantification of empathizing characteristics might more accurately predict aptness for the career of nursing than GPA (Penprase et al 2013). Salespeople that are empathetic build and maintain long-term profitable customer relations since they are better able to understand their customer's needs (Delpechitre 2013). In the field of teaching, the application of empathy helps teachers to better understand the worlds of the children who they teach. (Warren 2013). In the area of management, empathy can help managers to establish a rapport with their employees and to gauge how new ideas will be accepted. Employees will also perform better for the manager who has shown them care (Somogyi et al 2013). These examples of the need for empathy in career success demonstrate how design-based education with a focus on empathy and the use of design methods that promote empathy are not beneficial only to students who will go to careers in design, but are in fact beneficial to all students, as the skill of empathy is a key skill for success in the twenty-first century.

5. Making a Case for Design Based Learning at primary and secondary level

While there is little literature available on Design education specifically for the elementary level, there is literature on design education at secondary school. Design professor, Meredith Davis has expressed concern for the lack of design education at secondary level in the United States and argues for the inclusion of design education in the preparation of teachers and administrators, as it offers strategies for improving teaching and learning (Davis 1998). She writes about a group of design professionals including architects, graphic designers, industrial designers, landscape architects and planners who seek to 'expand the pedagogical repertoire' of teachers through design – not by introducing a new subject, but by helping them to use design to deliver existing content to improve student academic performance (Davis 1998). Davis describes design as 'a social, not individual, production and therefore shares responsibility for its outcome with the audiences who make meaning of it through its use' (Davis 1998). She describes the design process as:

> This cyclical process begins with the identification of a problem, involves research and the ranking of priori¬ties that often appear to be in competition with each other, tests the viability of multiple solutions through prototypes, and ends with the evaluation of objects against a socially mediated set of performance criteria" (Davis 1998).

Recognizing that future satisfaction in life and work depend on creative problem solving, design educator Robin Vande Zande also makes a case for design education in secondary education stating that art and design education can help train students in problem solving through the design process (Vande Zande et al 2014).

Design Thinking challenges students to find solutions to complex and open-ended problems (Carroll, et al 2010). Design Thinking supports students academic performance in 'core' subjects by contributing to critical thinking, social development, teamwork skills and the skill of negotiating meaning (Carroll, et al 2010). Vande Zande also purports that understanding the Design Process can help students become more critical thinkers (Watson 2015).

Recent research with Design education at secondary level

Several researchers are moving away from the traditional argument of design being able to support the academic output of students and are examining the way that design process and design thinking can generate other types of results when introduced at secondary level. In Canada, Aflatoony and Wakkary explored whether or how students could apply Design Thinking principles to problem solving in other courses and to everyday life situations. In their study they found that students transferred and applied design thinking techniques in real-life problem-solving situations; and found that the problem finding and problem-solving techniques of design empowered students, and encouraged critical thinking (Aflatoony and Wakkary 2015). In Latvia, Freimane compared responses to the same design brief by two disparate groups, the first a group of Master's level design students and the second school-aged children 11 – 14 years old. In her findings she affirmed that children were able to create new and innovative product concepts and to understand the systems approach of design thinking, though she recognizes the impossibility of assessing the impact of sustained exposure to design without a longitudinal study of 20 – 30 years (Freimane 2015). Carroll et al, in their project 'Taking Design Thinking to Schools Research Project in the

United States, focused on three core questions: how did students express their understanding of design thinking, how did affective elements impact design thinking in the classroom as well as a more traditional research focus of how design thinking connected to academic standards and the acquisition of content. (Carroll, et al 2010). They surmise that design thinking activities encouraged students to engage in collaborative learning, and design-thinking projects promoted engagement by allowing students the opportunity to express their opinions and finally that design thinking challenges students to think in new ways and take risks (Carroll, et al 2010).

6. Conclusion

There is recognition on many levels of the inadequacies of current education paradigms in developing 21st century skills and predictors of student success such as a growth mindset. Design education through its signature pedagogies, methods and processes already develops many of these skills. The parallel between these skills and the skills imparted through Design Thinking and Design education seem to suggest a significant opportunity for a new design-based education paradigm that focuses on design abductive reasoning and cognitive skills like curiosity, innovation and critical thinking as well as the development of social skills such as empathy, facilitation and collaboration. The need for the skill of empathy in a diverse range of professions, and to the 21st century skills in general also suggests that exposure to design education at primary school could lay a solid foundation that would not only benefit children who go on to become creative professionals, but would in fact benefit all children and lead to their greater engagement at school and future success in their professional lives. The success of the recent experiments with Design Education at primary and secondary lays a foundation for additional experimentation.

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