Why a Logbook? A backpack journey as a metaphor for product design education

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Abstract: Recent literature suggests that the development of cognitive skills should constitute explicit learning objectives in design education. The work describes an educational intervention designed with the intention of promoting the creative and critical thinking performance of a group of Portuguese design students. To this end, creativity and critical thinking tests, pre and post intervention, were applied to the experimental group and to a control group. The intervention was based on two fundamental theoretical assumptions: (1) students’ thinking skills can be promoted by the introduction of Design Thinking as a learning content, and (2) this work should be complemented by the promotion of students’ metacognitive reflection. Comparing the learning process, by analogy, with a backpack journey, a Logbook concept as an educational tool to potentially promote students’ self-reflection was developed. Compared with the control group, results indicate a positive evolution of creative thinking skills in the experimental group.

Keywords: Design education, Design Thinking, Creative thinking, Critical thinking, Learning journals

1. Introduction

Modern liquidity, as described by Bauman (2000), is a very suitable expression to help to grasp the nature of the volatile markets of the 21st century. Under ever-changing contexts, there is an increasing demand for design professionals who have the wide perspective that is needed in the complex environment we face today and we are likely to face in the future. Employers no longer value professionals who only exhibit technical expertise. Ways of thinking, including creativity, critical thinking and metacognition, constitute key competencies for 21st century professionals and citizens (Binkley, Erstad, Hermna, Raizen, Ripley, Miller-Ricci & Rumble, 2012; Buchanan, 2001; Samavedham, 2006).

In the specific case of design education, authors such as Tovey (2012) and Wells (2013), classify thinking skills as the more important capacities for a design professional, arguing that design
education should prepare students in self-knowledge, self-awareness, and design thinking. According to Jou & Wang (2015), thinking skills should become the core of design education:

“We are living in an era where consumer requirements and demands are changing rapidly. Product designs, which used to be simple, require increasingly intricate, complex and aesthetic features. (...) As a result, the instruction of student creative thinking skills has become an important topic of research. (...) everything from student learning activities to every single act of human invention is wholly dependent on thinking skills, making them the core of learning.” (p. 818)

Cartier (2011) stresses that, according to the International Council of Societies of Industrial Design, the exit profile of design graduate students places thinking skills above technical skills. However, as recognised by several authors, the development of thinking skills capacities has not been privileged by teaching and learning strategies classically applied in design schools (Li et al., 2006; Wong & Siu, 2011; Lloyd, 2012). On the contrary, most programmes are mainly focused on technical skills, which apparently are more immediately related to professional practice (Hargrove, 2013).

This work reports on an empirical study about a didactic intervention where an educational tool, specifically conceived to promote students’ cognitive skills within the product design project, was applied. The intervention was based on two fundamental theoretical assumptions: (1) students’ creative and critical thinking skills can be promoted by the introduction of Design Thinking as a learning content, and (2) this work should be enriched by the promotion of students’ metacognitive reflection. Although a few empirical studies about creative thinking in design education were found in literature (White, Wood & Jensen, 2012, Budge, 2013; Kramer, 2014), none of them included critical thinking. However, some of those studies also point to the relevance of metacognitive reflection (van de Kamp, Admiraal, van Drie & Rijlaarsdam, 2015; Lee & Wong, 2015).

2. Theoretical background

Creative thinking, according to the framework of Torrance (1979), is measured by four criteria: fluency (production of a great number of ideas), flexibility (different perspectives and points of view), originality (unique or unusual ideas in a given context), and elaboration (which is allied to the capacity to enhance those ideas by providing additional detail). On the other hand, and according to Ennis’ (1987), critical thinking is a reasonable and reflective thought process focused on deciding what to believe or do, in which the author includes a list of abilities, such as focusing on a question, analysing arguments or asking and answering clarification questions, and dispositions -for example, being alert for alternatives or being open-minded.

Design Thinking, a concept originally emerged in design research cognition, expresses the way experienced designers usually approach design problems. Design problems are characterised by being ill defined, ill structured and open. Since the twenteens, Design Thinking is not only seen as a motor for innovation, but it offers new process models which help to accelerate, visualise and improve every creative process, carried out in multidisciplinary teams, including designers (Tschimmel, 2012). Design Thinking models aim to replicate the iterative character of a creative process, and the alternation between divergence and convergence moments, inherent in design problem solving. In recent decades, several Design Thinking models and toolkits have been developed. In the didactic intervention reported here, the Evolution 6² Design Thinking model (Figure 1), proposed by Tschimmel (2014), was applied.

The E6² model divides the Design Thinking process into six phases: Emergence, Empathy, Experimentation, Elaboration, Exposition and Extension. Each phase comprises two sub phases
(Exploration and Evaluation) corresponding to moments of divergence and convergence. This characteristic makes the E6² model consistent with the interdependent approach between creative and critical thinking, sustained by the authors of this paper (Clemente, Tschimmel & Vieira 2016). The fact that the E6² model also suggests a set of 36 tools that students can apply to each phase of their own design projects is also an advantage. Therefore, the model E6² was used as a didactic content of our intervention. (A full version of the model and associated tools can be found in https://pt.pinterest.com/mindshakept/evolution-62-mindshake-design-thinking-model/).

Due to the growing application of Design Thinking in several innovation areas, some specialists argue that there’s a risk that Design Thinking can be seen just as a toolbox of “designer’s specific methods taken out of context” or a “ready to use” creativity tool (Johansson-Skölberg, Woodilla & Çetinkaya, 2013, p. 131). To overcome these concerns, the learning of Design Thinking also needs to include explicit learning of metacognitive competences “beyond isolated information acquisition (…) towards a holistic learning through experience and reflection in projects” (Scheer, Noweski & Meinel, 2012, p. 8).

![Figure 1. E6² Design Thinking Model](image)

Metacognition, or thinking about cognition, involves self KNOWLEDGE and control skills for regulating one’s cognitive activities. Metacognitive skills are related “with awareness, observation, reflection and analysis which is needed to become an independent learner” (Sart, 2014, p. 131). Some authors claim that “students have to become conscious managers of their own cognitive abilities”, their “own strengths and weaknesses” as thinkers so they can find “ways to use these strengths and mitigate the weaknesses” (Tschimmel, 2006, p. 673). According to Kim & Kim (2013), design problems require the mobilisation of different thinking styles. Within the context of the present work, we propose that students have to develop the ability to self-reflect on their own cognitive abilities which constitute a form of metacognition.
Several proposals regarding thinking styles classification in the field of creative problem solving have been presented, over the last 20 years, by authors such as Herrmann (1995), Basadur & Gelade (2003) or Puccio, Murdock and Mance (2007). Although those proposals were not necessarily developed in the design field, they provide an important framework for the development of taxonomies for that specific domain, including the one here presented. Relevant work developed by authors from design cognition such as Cross (2007) and Dorst (2006) was naturally taken in consideration.

3. The exploratory backpack journey metaphor

Metaphors are “used to describe phenomena or patterns of mental constructs as if they were something else – something more familiar”. Metaphoric descriptions of the design process have been usefully used because they “enable the grouping of concepts at lower levels of abstraction into memorable patterns” (Love, 2000, p. 302-303).

The experiment here reported was based upon the metaphoric comparison of the learning process in design courses, with an exploratory “backpack journey”. The travel here invoked does not correspond to just any kind of journey, but specifically to an exploratory travel with an unknown destination and, forcing the analogy, where even the beginning is not always clearly defined. An exploratory journey may follow a global plan, but never a rigid framework. Likewise, design problems evolve as they progress, being redefined and reconfigured as the solution begins to emerge.

As explained by Cross (2007), “design is exploratory” and a design brief is “a partial map of unknown territory” (p.52). On a similar analogy, Dorst (2006) compares the creative design process to a walk through an unexplored territory: “there is a general direction you want to go in, but no trails. (...) Deciding whether to climb a mountain, or go around it, are difficult choices to be made if you do not know their consequences” (p.219). Dorst’s analogy refers specifically to the type of voyage associated with a nineteenth-century explorer in search of something new, such as the “source of the Nile”. Such a journey, not completely defined, neither planned nor structured, requires the ability to make decisions, take risks and deal with uncertainty. It involves dealing with advances and setbacks, as travellers face changes, obstacles, choices and opportunities. It requires the ability to manage time, deadlines, goals, resources and the capacity to seek and recognise important and credible information. At the same time, travellers need to maintain an inquisitive, open, observant and motivated attitude. Finally, a reflective mindset is also required, allowing explorers to learn and to create useful memories from the travel experience.

The clear distinction about the type of journey to which the metaphor refers is fairly important. Tedder and Lawy (2013), who applied a similar analogy in the context of teacher education, cautioned:

“Are the students to be like tourists on a standard package holiday (...)? Or are they to be more like travellers engaged in informed and reflective discussion, expertly supported in a journey of discovery leading to a qualification that recognises not only evidence but also the distance travelled in professional development?” (p. 67-68)

Salavisa (2008) brought the important distinction between the explorer and the tourist to our attention. The author explains that the figure of the tourist appeared, historically, with the democratisation of travel, as this became accessible to the middle classes. Before that, travel was exclusively for the privileged classes. Among them, it was usual to provide the youth with a cultural and educational journey, serving as a complement to formal education. But, for the tourist, travel no
longer involves the pleasure of discovery and the search for the unknown. The tourist is an observer who looks at the places he passes in a distant, fleeting and superficial way.

When Salavisa (2008) refers to the historical context within the evolution of a journey, he was arguing how important it is, to artists and designers, to keep a travel diary. Often referred as “a field notebook”, in the context of biology and geology, or, as Le Corbusier called it, the "Patient Search Notebook", the travel diary helps the traveller to be attentive to the things that surround him, teaching him to see, rather than simply to look. It also introduces a personal narrative, reminding the traveller of a continuous interior dialogue where how it is seen is more important than what is seen.

The concept of an individual Logbook, as a means to record and reflect on the journey, intends specifically to promote the exploratory approach, rather than the touristic one, to the design project journey. Although a design project is usually a collective experience, the developed Logbook intends to induce each student to reflect on his personal trajectory through the design project.

The developed Logbook fits into the definition of learning journals of Moon (2006) according to whom a learning journal is essentially a vehicle for oriented self-reflection. In comparison with other freer types of learning journals, such as learning portfolios, in which the student constructs his own narrative about the events that he considers more relevant (Vieira F., 2005), a Logbook provides a much more structured template. In fact, the Logbook designation was chosen precisely because it requires a factual record of date and location. The logbook assumed the form of an individual map consisting of a A3 sheet, where each student has to reflect on his own work on the design project with which he is involved on a weekly basis. Each week the student has to record the time (project week number) and, according to the project activities developed in that same week, the “location” of the project as described by E6\textsuperscript{2} model phases and sub-phases. E6\textsuperscript{2} Design Thinking model can be seen as a travel map where the model’s phases and sub-phases correspond to the journey’s locations.

It is interesting to notice that Lerma, Palù & Giorgi (2014), when describing the design learning process applied at the Politecnico di Torino, which is intended to incorporate exploratory capacities into its students’ learning, also applied the terms “navigator” and “explorer” to “designer" (p. 145). This also refers to the idea of an exploratory travel through the unknown. What we are asserting is that the navigator-designer, or explorer, has to play different roles within the different design project phases. In this respect, Dorst (2006) compares a designers’ cognitive profile to a platypus, “with his duck’ beak, webbed feet, furry coat and the habit of producing eggs”. Moreover, the student has to be aware of those cognitive styles and of the moments that he has to alternate between them, favouring some in detriment to others, “fluently flowing from one to the other” (p. 81).

To include that cognitive approach, and to encourage students to apply metacognitive reflection, a complementary taxonomy of cognitive styles (Table 1) was also conceived and included in the Logbook (Clemente et. al. 2016).

Table 1. Thinking Styles Taxonomy
| Job (Thinking style)          | Attitudes                                                                 | Actions                                                                 | Creative Thought (Torrance) | Critical Thought (Ennis) |
|------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------|--------------------------|
| **Artist (Imaginative)**     | Unconventional Fun                                                          | Generates a lot (a "torrent") of ideas                               | Fluency                    | Originality              |
|                              | Observer with all senses                                                    |                                                                        | Flexibility                |                          |
|                              | Emotional Dreamer                                                           |                                                                        |                            |                          |
|                              | With a certain amount of madness                                           |                                                                        |                            |                          |
| **Olympic Athlete (Focused)**| Ambitious, Visionary                                                       | Focused on Objectives                                                 | Fluency                    | Focus                    |
|                              | Injects huge amounts of time and energy in their work                      | Distinguishes the essential from the irrelevant                       |                            | Clarity                  |
|                              | Attention and concentration in field                                        | Has a clear vision of the desired output                              |                            |                          |
| **Surgeon (Determined)**     | Lives well with uncertainty and ambiguity                                  | Performs activities to achieve objectives                             | Elaboration                | Inferences               |
|                              | Determined, Independent                                                    | Takes into account deadlines and events                                |                            |                          |
|                              | Sees error and failure as an opportunity to evolve                         | Takes advantage of the skills of each team member.                    |                            |                          |
|                              | Relies on his own intuition                                                |                                                                        |                            |                          |
|                              | Ability to work / manage a multidisciplinary team                          |                                                                        |                            |                          |
| **Anthropologist (Empathic)**| Impartial                                                                  | Puts himself in the role of the other                                | Flexibility                | Situation                |
|                              | Rejects preconceived ideas                                                 | Identities and assess the emotional state of another                  |                            | Clarity                  |
|                              | Curious                                                                    | Relates various information about a context to achieve a holistic picture|                            |                          |
|                              | Thirsty for knowledge                                                      |                                                                        |                            |                          |
|                              | Sensitive                                                                  |                                                                        |                            |                          |
|                              | Attentive to details                                                       |                                                                        |                            |                          |
| **Judge (Analytical & Evaluative)** | Disciplined, Rigorous, Shrewd, Cautious                                     | Evaluates ideas according to predefined criteria                       | Elaboration                | Reasons                  |
| **Professional Traveller (Holistic)** | Ability to plan, manage and control the process                            | Sees the process as a whole                                          | Flexibility                | Overview                 |
|                              | Global and systemic thinking                                               | Understands the structure of the problem                              |                            |                          |
|                              | Ability to take advantage of the merits (strengths)                        | Determines the next step of the process                               |                            |                          |
|                              | Acceptance of chaos, Openness with respect to random events                |                                                                        |                            |                          |
| **Travel Writer (Reflexive)** | Self-conscious                                                             | Analyses the driven learning process                                  |                            | Inferences               |
|                              | Ability to take advantage of the merits (strengths)                        | Reflects on experiences, transforming them into useful knowledge       |                            |                          |
|                              | Recognise personal singularities and use then to their advantage           |                                                                        |                            |                          |
Cognitive style refers to the way individuals think, perceive and process information for solving problems (Orcik & Vrgovic, 2014, p. 831). In the present work, “cognitive style” refers to the preferable set of “thinking styles” each student mobilises in problem solving. The developed taxonomy indicates seven thinking styles and relates each one of those styles with a profession and the behaviour and attitudes required by that activity: Imaginative (Artist), Focused (Olympic athlete), Determined (Surgeon), Empathic (Anthropologist), Analytical and evaluative (Judge), Holistic (Professional traveller) and Reflexive (Travel writer). That parallelism is expected to facilitate taxonomy comprehension and memorisation by students. Each cognitive style within the taxonomy is also aligned with creative and critical thinking capacities.

Figure 2 summarises the three above described instruments applied to the implemented intervention: (i) the E$6^2$ model, as a travel map, (ii) the individual Logbook, not only as a written record of time and place, but also as a guided metacognitive self-reflection template and, finally, (iii) the Thinking Styles Taxonomy.

Figure 2. Learning tools applied under the Exploratory Backpack Travel metaphor didactic intervention

Figure 3 shows an example of a student filling her own Logbook with help of the complete Thinking Styles Taxonomy.

Logbook filling requires each student to select the cognitive style(s) he has felt the need to activate during a certain project week. By this means, students are guided on the reflection on their own thinking process throughout the project, being explicitly induced to engage in metacognitive activities. To give an example, on a given week of the project, if a student is involved in interviewing potential users of the product being developed, he should mark the phase of Empathy and the sub-phase of Exploration on the E$6^2$ model as “locations” of the map. Reflecting on the cognitive styles that were more mobilised on this activity, the student will probably assign the Empathic thinking style associated with the anthropological job.
4. Methodology

Our research aimed at answering the following research question: What is the effect of the implemented intervention on students’ creative and critical performance? Students’ pre intervention creative and critical performance was diagnosed by the application of the TAEC creativity test (de la Torre, 1991) and Cornell’s Critical Thinking test (Ennis & Millman, 1995). De la Torre’s TAEC creativity test is based on 12 given figures which must be completed in a free graphic interpretation within 20 minutes. Different criteria such as resistance to closure, originality, elaboration, fantasy, connectivity, extent and graphic ability were used to evaluate the results. The Cornell Critical Thinking Test – Level X is a (usually) 50-minute timed written multiple choice test, requiring the reading of a short fictional story and then answering a set of 76 questions that evaluate students’ critical performance, including the following skills: induction, deduction, credibility and identification of assumptions.

The investigation was conducted as part of a degree course in product design at a Portuguese Polytechnic. The intervention was made on two courses over twelve plus four weeks. In the first course, Product Development Project II, within the PBL methodological approach, students had to develop a small kitchen appliance aimed at promoting healthy eating habits. Students were organised in groups of two, and each group proposed a different concept to develop, such as for example, a puree moulder or a juice machine with pulp regulation. The four project tutors of the weekly three-hour class all had backgrounds in design and engineering. The didactic intervention consisted of twelve weekly sessions of approximately 45 minutes conducted by the main investigator who has a background in mechanical engineering and a post-graduation in education. In these sessions, the E6^2 model was explained as well as some suggested techniques such as the Mind Map, Analogies or Storyboarding. After introducing the logbook concept, the thinking styles taxonomy was presented and discussed. In each session, each student was encouraged to reflect on his individual design project journey through the phases and sub-phases of the E6^2 model and cognitive styles, by filling in his individual copy of the logbook. The second part of the intervention occurred during the first four weeks of the following semester on the Communication Techniques course. On this part of the intervention, each student had to analyse his own logbook and, from there, develop his own digital storytelling expressing their own cognitive profile as a future product designer in a 2 minute auto-biographic video containing original images and text. The activity was supervised by the course teacher, the main investigator and by an invited investigator specialised in digital storytelling.
The experimental group was composed of 15 students, 40% male and 60% female, with an average age of 21.07 years. The criteria for their inclusion in the group were: (i) that they attended all courses that were an object of the intervention (ii) that they voluntarily participated in all activities proposed by the investigators and (iii) that they had no difficulties in reading comprehension that could affect their critical thinking test response. The control group was composed of 12 students, 50% male and 50% female, with an average age of 22.23 years old. Both groups belong to public Polytechnics in North Portugal.

Results triangulation was assured by listening to the perceptions of students and teachers, who were not members of the investigation team, about the intervention. Students answered to written questionnaires and teachers participated in two 60 minutes focus group sessions, recorded on video and the dialogues’ transcription was validated by all the participants.

5. Results and Discussion

Pre and post intervention results from both tests in both groups were evaluated as shown in Table 2. Those values were also compared with reference values provided by De la Torre (1991) and Vieira (2014).

| Group         | n  | TAEC Creativity | Cornell Critical Thinking |
|---------------|----|-----------------|---------------------------|
|               | Pre | Post            | Pre | Post |
| Control       | 12  | 75.5            | 72.3| 28.1 | 29.3 |
| Experimental  | 15  | 42.4            | 72.3| 30.3 | 28.4 |
| Reference Value | 100.0 | 34.8 |

Results show that the intervention improved students’ creative performance, although no significant improvement was noticed on the critical performance. Differences between the two groups were evaluated through hypothesis tests (Tables 3 and 4). When data normality was verified, a paired t-test was used to compare the means pre and post intervention. When normality was not verified, a Wilcoxon test was applied. Data was treated using IBM SPSS Statistics 23 package. Statistically significant differences were found only on the experimental group, and only on the creativity test. As an example, Figure 4 shows the results before and after the intervention, from the same student.

The authors believe that the positive results observed with respect to creative thinking can be related to the ability that students developed to perceive the thinking styles they should and they should not activate when generating ideas. On the other hand, the authors recognise that during the intervention, critical thinking was not addressed with the same regularity and clarity as creative thinking, which may explain the weaker observed results. To overcome this limitation, the authors are now working on a fourth instrument consisting of a set of questions specifically formulated to promote students’ critical thinking within product design projects.
The value of the metaphoric description of the design process as an exploratory travel and the resulting thinking styles taxonomy was supported by the positive feedback from students and teachers. The main advantage of the tools pointed out by teachers, was the fact they promote students self-reflection and self-knowledge at the same time as helping students to manage and guide their own course of action through the project. Teachers were very secure about the advantage of the taxonomy being based on a metaphor which students can easily understand. That perception is aligned with Burnette’s (2013) position when he states that “a suitable theory must recognise the need for compression of neural complexity into representations that can be recognised, interpreted, transformed and applied by ordinary people” (p. 1). Students’ perceptions were also positive as shown in Table 3.

| Question                                                                 | Average | Mode | Median |
|--------------------------------------------------------------------------|---------|------|--------|
| I recognise the similarities between the product design process and a backpack journey | 6.67    | 7    | 7      |
| I can see the interest in recording the design process the process development on a Logbook | 6.80    | 8    | 8      |
| Self-reflexion about thinking styles is facilitated by the jobs personification | 6.25    | 7    | 7      |
| Self-reflexion about thinking styles helps me to identify my strengths and weaknesses as a future designer | 6.86    | 8    | 8      |

In general, it is evident that both teachers and students welcome the intervention favourably and the applied tools. Results also suggest that the intervention contributed to the students’ creative capacities improvement.
6. Conclusions

A twelve plus four-week didactic intervention aiming to promote students creative and critical thinking skills within design education context was reported. The main idea behind the intervention was the metaphor between a design project and a backpack trip, or exploratory journey. An individual Logbook, as a learning tool that allows each student to individually record and reflect on his personal journey through the design project, was applied. Students metacognitive reflection was encouraged through the introduction of a new seven category taxonomy of cognitive styles. Students’ creative and critical performance before and after the intervention were evaluated and compared with a control group. Although the intervention did not produce a significant effect on the critical performance of participants, it clearly contributed to students’ creative performance enhancement. At the end of the intervention, both teachers and students involved agreed on the value of the proposed metaphor and instruments especially on helping students to manage and guide their own course of action through the project as well as to identify their own strengths and weaknesses as a future designers.

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