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Design and Technology Education: An International Journal

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Design and Technology Education: An International Journal
(formerly The Journal of Design and Technology Education) is published three times a year.

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Tel: 01789 473902
Fax: 01789 841955

email: membership@data.org.uk

Design and Technology Education: An International Journal is available in the online shop at: www.data.org.uk

Volume 24
Number 1
ISSN 2040-8633 (online)
Spring 2019

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Editorial: Design processes at the heart of the matter

Kay Stables, Editor

Goldsmiths, University of London, UK

Welcome to the first issue for 2019 of Design and Technology Education: An International Journal (now routinely referred to as the DATE Journal). As with previous issues, we have a good collection of research articles, drawn from both school and higher education. Across these articles the contexts are very different, with authors from Finland, Netherlands, Turkey, United Kingdom and United States of America and articles spread across a range of design disciplines. What all have in common is a consistent focus on the importance of placing design processes at the core of learning and making these explicit though student project work.

But first, with this issue, we also have some changes to report. The first of these is an Editorial change. For the last four years, the Journal has been jointly edited by Kay Stables and Erik Bohemia. Unfortunately, pressure from other aspects of Erik's academic life have created the need for him to step down from this role. Over the last four years Erik has made a valuable contribution, not least in promoting the journal to a wider audience and instigating the Guest Edited sections, the first of which was included in Issue 23.2, with a set of articles developed from selected papers for the 2017 Engineering and Product Design Education (EPDE) conference. Fortunately, Erik is not leaving the Editorial Board and so will still play a part in the development of the Journal.

The decision to create a joint editorship was made as a way to address the growing breadth of articles received by the Journal, including those coming from design in higher education. Kay's experience is predominantly in schools' education and Erik's in higher education. To continue with this approach, we are delighted to announce that Eur Ing Dr Lyndon Buck from Buckinghamshire New University has agreed to accept the role of co-editor of the Journal. Lyndon will be known to the higher education design community and also to readers of this journal in his role of Guest Editor for the special section of articles from the EPDE conference published in issue 23.2.

A second change has been caused by Richard Kimbell's decision to 'hang up his *reflections* hat' after twenty years of writing a reflection for every issue of the journal. Richard's reflection pieces, thought provoking, amusing and serious at the same time and based on his nearly 50 years teaching and researching design and technology education, have been enjoyed by many readers. The first ten years were collected together in a single book and plans are now afoot to create a second edition of following ten years. Richard's contribution goes way beyond the reflections. He also was Editor of the Journal for ten years (1995-2004) and has also contributed articles from his own research. We owe him a deal of thanks for his role in the success of the journal. We also look forward to future contributions of research articles (watch this space).

Richard stepping down has left us pondering what to do with the ‘reflections’ section. While we work on this we will be inviting guest reflections, the first of which is in this issue and is by Tony Ryan. Tony is just over one year into his role as CEO of The Design and Technology Association – the Professional Association for UK Design and Technology Educators and the sponsor of the DATE Journal – it seems a fitting opportunity to hear what is on his mind!

A final change that was instigated last year was, in addition to the Editorial Board, to introduce a panel of reviewers. This has allowed us to broaden the review expertise for the Journal and also to spread the workload as the Journal attracts increasing numbers of submissions. While the panel has done both of these things, there are still areas where additional reviewers would be helpful and we would welcome expressions of interest, particularly from researchers with experience in primary education and higher education.

Reflection

The first ‘reflection’ article of 2019 has been provided by Tony Ryan. Tony’s background is as both a Design and Technology teacher and as Headteacher of two large urban secondary schools for 11-18 year olds. He reflects on a set of current issues in the English school system as he considers whether the current system is fit for purpose. While his reflections relate specifically to England, it would be interesting to consider if his reflections have resonance with education systems elsewhere in the world, or whether they are unique to England. What are the priorities at the core of national education systems? And do they match up with those things valued by learners and their parents? Please let us know if you have comments to contribute.

Articles

The first article in this issue is a systematic literature review that is prompted by a need for teachers in basic education (school education from age 7 to age 16) to understand how technology and computational thinking can be introduced into active learning in craft education. In *Beyond Programming and Crafts: Towards Computational Thinking in Basic Education*, Sinikka Pöllänen (University of Eastern Finland) and Kari Pöllänen (Cloudia Ltd, Finland) analyse literature to address two research questions: how programming is described through craft science-based concepts of craft labour; and examples that exist to teach programming in crafts education. In contextualising craft education in Finland, they point to their national curriculum that sees craft as multi-material with design-based holistic craft processes. Through a systematic, far-reaching and representative review they identified 10 texts that informed on the first research question and 68 on the second, allowing them to distinguish literature that provided insight into both programming as a craft and computational thinking in crafts. This allowed them to see convincing parallels between programming and crafting and to provide a wealth of perspectives on the potential for computational thinking and programming to be taught through craft. While situated within the Finnish curriculum, this article has much to offer to school and tertiary design and technology educators, showing how computational thinking, seen broadly, can enrich learning and teaching activities.

The next two articles both focus on developing students' ability to focus more on the end users of their designing.

In *An Instructional Model for Social Design Education: A Design Project for Stray Animals Including Production-Based Learning Approach*, Güçlü Yavuzcan and Damla Şahin (Gazi University, Turkey), Barış Gür (Venn Design Ltd, Turkey) and Özden Sevgül and Cemil Yavuz (Gazi University, Turkey) report on research that involved developing new methodologies to integrate social design into industrial design education. The article presents a social design toolkit and reports on a project where it was employed in which students worked in groups, designing in the context of animal welfare. This topic was chosen as one where there is limited evidence of projects in this context and also it allowed students to work directly with immediate issues of stray dogs on the university campus. The research took a design thinking and production based learning model where students were designing, prototyping and building full size, fully functioning, stray animal shelters. They worked in teams and consulted with stakeholders. Based on observation of projects, interviews with instructors, post-project questionnaires with the students and instructor assessments the research concluded that the model had improved learning outcomes. The article is particularly valuable for the detailed account of the toolkit and of the projects undertaken, which highlight the value of a real-world (as opposed to hypothetical) project and the impact of collaborating with stakeholders.

In *Empathy Thresholds in Transport Design Students*, Andree Woodcock, Jane Osmond, Michael Tovey (Coventry University, UK) & Deana McDonagh (University of Illinois, USA), highlight the importance of student designers developing empathy with the users of their designs. Threy explore the possibility that empathy could be considered as a threshold concept and capability that student designers need to achieve. Providing insight from previous research into the nature of a threshold concept as being transformational, irreversible, integrative and troublesome, the article makes a clear case for the value of identifying threshold concepts for designing and also the challenges for students in progressing to and through them. The authors report on the use of Discrete Learning Interventions (DLIs) that were used across different cohorts aimed at teaching empathy and that were designed to take students through four stages: discovery, immersion, connection and detachment. The aim of the interventions was increase participants' empathy towards older transport users. Results showed the difficulty students found putting themselves in the space of users who were radically different to themselves and also the challenge this presents to design educators. What is clear from the research is the importance of seeing empathy as a threshold concept and the importance of developing pedagogic approaches to enabling students to pass through this threshold.

The final three articles each provide insight into different aspects of processes of design.

The first of these article focuses on a question of whether and how design educators articulate designerly actions and skills. In *The tacit design process in architectural design education* Elise van Dooren, Machiel van Dorst, and Thijs Asselbergs, (TU Delft, Netherlands) and Jeroen van Merrienboer (Maastricht University, Netherlands) and Els Boshuizen, (Open University, The Netherlands & University of Turku, Finland) explore this question in the context of architecture education through a case study approach, analysing videos of tutorial sessions with first year architecture students. The analysis uses a framework developed and used in previous research with practicing designers that identified five generic elements of design processes: experimenting; a guiding theme; particular domains (architecture examples including form and space, physical context/site, socio-cultural/economic/historic/philosophical); frame of reference; physical language (or laboratory) of experimenting (their example, sketching and modelling). Tutorials were analysed with regard to different actions and skills of design processes and the extent to which the teachers were implicit or explicit about processes. This analysis then linked to the five generic elements. The insights provide a rich level of detail about the ways in which the tutorials were conducted, with an overarching conclusion that teachers largely do not articulate the "how and why of the design process in general", much being implicit, despite research evidence from elsewhere that making design processes explicit can speed up student learning processes.

The next article that has a design process dimension focuses on supporting students' creativity. In *Evaluation of strategies of creativity development used in store design projects based on student projects*, Seval Özgel Felek (Ordu University, Turkey) and Özge Gül (Dogus University, Turkey) report on research undertaken in a second level interior architecture studio project. Through a broad ranging literature review, the authors make a valuable case for a need to develop students' strategies for creativity, particularly as a means to support innovation. They highlight a large number of potential strategies, and then report on the specific use of two strategies, chosen to meet perceived needs of the students in question and of their project that was a design challenge of producing alternative layouts for a retail store design. The two strategies, "Dead Head Deadline" and "Merged Ideas in a Box and Circle of Opportunity", are described, along with their use in the students' projects. Data was drawn from an analysis of the students' work and questionnaire feedback from the students about the use of the strategies. Although a small-scale research project, both sources gave clear indications of the impact of introducing the strategies, both within the project in question and potential future use identified by the students.

The final research article providing insight into design processes turns attention to students' attitudes towards the use of software applications. In *Evaluation of the Relationship between the Use of Multi-Software and the Students' Attitude towards*

Computers and Technology in Undergraduate Architectural Design Studio Education, Asli Agirbas (Fatih Sultan Mehmet Vakif University, Istanbul, Turkey) raises the issue of the increasing number of architecture related computer programs becoming available and in his research explores the relationship between the use of multi software and students' attitudes towards computers and technology. Drawing on Kolb's model of experiential learning, the research focuses on second year architecture students and the range of different software programs used within a site-specific architecture design project that included a range of research and analysis requirements placing demands on students that could be helped by use of different programs. The article presents questionnaire data collected from the students on their use of computer programs and three high scoring projects that were evaluated in detail. The questionnaire data indicated a strong link between those students who have an interest in computers and a willingness to overcome challenges of using different software packages. The detailed project analysis showed that the high scoring students had used a wide range of software and that their choice of software linked closely to different phases of their projects' development: site analyses; early design sketches; modelling plans etc; and presenting their projects. As with the previous article, the research reported here is from a small-scale project. But it none-the-less highlights the importance of students linking the design purpose they have at any given stage on their process, with the tools that can directly assist with that purpose.

Finally, this issue has a review of *Drawing for Science, Invention and Discovery: even if you can't draw* by Paul Carney, published by Loughborough Design Press and reviewed by Alison Hardy of Nottingham Trent University, UK

Reflection.

The first 'reflection' article of 2019 has been provided by Tony Ryan, the Chief Executive Officer of the UK Design and Technology Association – a professional association for Design and Technology educators, and the sponsors of Design and Technology Education: An International Journal. Tony's background is as both a Design and Technology teacher and as Headteacher of two large urban secondary schools for 11-18 year olds. He reflects on a set of current issues in the English school system as he considers whether the current system is fit for purpose. While his reflections relate specifically to England, it would be interesting to consider if his reflections have resonance with education systems elsewhere in the world, or whether they are unique to England. What are the priorities at the core of national education systems? And do they match up with those things valued by learners and their parents? Please let us know if you have comments to contribute.

Kay Stables,

Editor

Is our education system fit for purpose?

Tony Ryan, CEO Design and Technology Association, UK

I have come to dread the question that often raises its head at social events "so what do you do?" As a secondary school headteacher this was often the start of a very short conversation, once you had declared your hand, the response was frequently something along the lines of "I could never do that" or the old favourite asking me what I did with my thirteen weeks holiday every year. As the Chief Executive Officer (CEO) of a charity championing design and technology, the conversation that follows usually starts with "wasn't that metalwork, woodwork and cooking?"

Everyone has a view on education, because everyone at some stage went to school. I have listened intently and politely on many an occasion while someone has taken me to task as a serving headteacher about the English education system and its inherent failings.

As a headteacher my first priority was to lead a school within which students felt safe and secure. I felt privileged that every morning, parents entrusted the safety and care of almost 1300 young people to my colleagues and I. For the most part, these parents had performed their due diligence, they had turned up at the open days held for prospective parents who were deciding which school they would wish their child to go to when they had completed their primary school education. They had attended the transition talk that helped them understand how the school managed the child's transition from primary to secondary school and the ethos and values that the 'new' school holds and had no doubt discussed their choice of secondary school with friends and neighbours. Many were swayed by their son/daughter's desire to go to a particular secondary school. I was always quietly in awe of just how much of the decision-making process actually lay with the students.

Reputation plays a greater role here than one might imagine, to some, the school was only as good as the last staff interaction with a parent, the 14-year-old student group on the bus on their way home, the last set of public examination results or your last school inspection report from the national Office for Standards in Education (Ofsted).

I would like to think that we were reflective as a school and asked the parents to complete questionnaires or surveys at least once a year, feeding back on what we did well, what could improve and what areas we should be developing. The response by parents prioritising what they wanted for their sons and daughters was scarily consistent:

- For them to be safe, confident and happy
- To have a group of friends that they could rely upon and trust
- It was important that their sons/daughters enjoyed school and wanted to be there
- The relationship between teachers and their students was often mentioned as a priority with parents recognising that nothing makes as much of an impact as a good teacher
- Discipline and order often came high up the list
- Extra-curricular activities and opportunities for students to try out new experiences, find gifts that they didn't know they possessed or to visit other countries was another plus for parents
- Surprisingly low down the list of priorities (possibly taken for granted) was the ability to gain a body of knowledge that would ultimately lead to examination success.

One of my 'go to' books as a school leader was Guy Claxton's "What's the point of School - Rediscovering the heart of education" (Claxton, 2008). It was all too easy to allow yourself and others to get caught up in the school performance data, the threat of Ofsted, the next governing body meeting ... allowing the real purpose of school and education to get lost in a sea of nonsense. In this book, Claxton grounds the reader suggesting that, while examinations and student progress are both clearly important, education's key responsibility is to create inquisitive, enthusiastic learners who will go on to confidently address questions asked of them in a rapidly changing world. Who could argue with that vision for education?

All too often I hear business and industry leaders bemoan the fact that they often pretty much have their pick of highly qualified school leavers. They arrive at interview confident that their stream of A* and A grades will be enough to see them safely through the interview process, but stumble as soon as they are asked to talk about anything slightly off-piste. These students have been conditioned by an education system that asks little of them, other than to passively acquire pockets of knowledge before regurgitating this onto an examination paper. Knowledge is king, with skills and attributes consigned to the rubbish bin, if you can't measure it, it clearly has no value!

A few weeks ago, Carolyn Fairbairn Director General at the Confederation of British Industry (CBI), gave a talk at the UK Royal Society. In this talk Ms Fairbairn suggested that our education system, in its current form, is probably not fit for purpose and needed to urgently adapt to the requirements set by a changing world. In this talk, three new proposals were tabled:

- The question was asked if GCSE's[i] taken at age 16 are really necessary? Carolyn Fairbairn described them as being "intrusive and intensive, leaving little space for schools to teach the broader skills that employers' value". She continued "In a world where few employers even ask for GCSE results and there are better ways of assessing school performance, why should we require students to cram for a set of exams which feel increasingly anachronistic?"

- Secondly, she talked about the fact that today's students will live longer and will consequently spend longer in work, so should they logically not spend a longer time studying and preparing for work? A suggestion was made that the government should consider the possibility of every student being supported to take at least the first stage of a level four qualification.

- Finally, the CBI announced its intention to support employers to work with schools, colleges and universities to help them to adapt to this change.

I have a lot of empathy with the proposals tabled. In my time I have taught and been involved in a range of qualifications ranging from vocational certificates, CPVEs, GNVQs, through BTEC's, GCSE's, Applied Qualifications, Diplomas and A Levels[ii]. For two years I was fortunate to teach International Baccalaureate (IB) Design & Technology to a mixed ability group of post-16 students.

These students had a choice of taking A Levels or the IB Post 16 and despite not being the 'traditional academic profile' for the IB, they and their parents, had opted for the breadth and depth that this qualification offered. I had previously taught A Level D&T but this was different, the syllabus required students to master a core body of knowledge, but then demanded that they put this knowledge to work in order to solve real problems ... not unlike the 'new' D&T GCSE. The students absolutely loved it (as did I) our conversations dug deeper and deeper into design theory and practice as my students completely immersed themselves in the subject. Students gained strong grades and Russell Group /

leading university placements not just on their examination grades, but on their ability to talk with deep knowledge and passion about their studies; that is real education.

An extended period of study with exams at 18 (not dissimilar to many school systems beyond the UK) would provide space for state schools to provide the breadth of education expected and demanded within the private sector. This would address a social inequity and a gap between the sectors that is growing ever wider.

The concept of the expectation that every student would move to at least the first stage of a level four qualification is also exciting to me, so long as that first stage could be with an employer, as part of an apprenticeship or the foundation year to a degree.

Finally, we are seeing an increasing number of companies and sectors that want to engage with schools. Be they driven by need, self-interest or simply a desire to 'put something back into the system' this engagement can contextualise learning making it 'real' and helping students (and their teachers) to see first-hand careers that might excite and motivate them. For their part, employers can stretch their young graduate trainees bringing them out of their comfort zones and back to school and the employer can be more involved in shaping the school system that they rely upon so heavily.

For the above to happen we need a government (of whatever colour) prepared to step back and look at the fundamental changes (real and emerging) to almost every sector of society, and to then be brave enough to design and implement a system that looks beyond political rhetoric and short-termism, to the real needs of students, business and society. I live in hope!

[i] GCSE – (General Certificate of Education) are external, national examinations taken typically by 16-year olds in English schools

[ii] CPVE - Certificate of Pre-Vocational Education; GNVQ - General National Vocational Qualifications; BTEC - Business and Technical Council; A Level – Advanced Level national examinations taken typically by 18-year olds in English schools, at the end of their formal schooling

Reference

Claxton, G., (2008). *What's the point of school? Rediscovering the heart of education*. One World Publications, Oxford, UK

Beyond Programming and Crafts: Towards Computational Thinking in Basic Education

Sinikka Pöllänen, University of Eastern Finland, Finland

Kari Pöllänen, Cloudia Ltd, Finland

Abstract

Continually increasing demands are being placed on the educational system to prepare students with technical skills due to the exponential implementation of information, technology and automation in the workforce. Students should work with design, problem-solving and computational methods and tools early on in their school lives in basic education and across diverse areas of learning. It has been argued that a fundamental understanding of technology requires computational thinking. However, teachers have difficulties integrating technology and programming into students' active learning in crafts. In this systematic literature review, the main aim is to view descriptions of programming through craft science-based concepts of craft labour and, thereafter, to seek examples to enable teaching programming in craft education during basic education. Considering the selection criteria to undertake the analysis, the final data set comprised of 10 articles dealing with programming and craft, and 68 articles describing the possibilities of combining crafting and programming in basic education. According to the results, it seems that contemporary multi-material and design-based holistic craft may encompass different forms of technology and programming such as prototyping, robotics, microcontrollers, 3D modelling, applications for documentation, visualisation, share-out and storytelling via multiple channels. These all help students to learn computational thinking as they start out with design and practical problems and proceed to technology-mediated programming skills. It is hoped that the findings will provide theoretical perspectives for practitioners and policymakers to see the mutual benefit arising from the integration of crafts, technology and computation in basic education.

Key words

basic education, computational thinking, craft, craft education, design and technology education, programming

Introduction

Computational thinking is argued to be a crucial skill for the 21st century due to the exponential implementation of information, technology and automation in the workforce (Wing, 2014). Thereby, increasing demands are being placed also on the educational system to prepare students with technical skills to live in our rapidly changing society (Pellegrino & Hilton, 2012). Students should work with design, problem-solving and computational methods and tools early on in their school lives in basic education and across diverse areas of learning (Papert, 1980; Barr & Stephenson, 2011; Foerster, 2016). Researchers (e.g., Wing, 2008; Webb et al., 2017) have noted that a fundamental understanding of technology requires computational thinking so that students recognise aspects of computation in the world that surrounds them. More widely, according to Wing (2006), everyone who uses computational tools and engages in step-by-step procedures needs computational thinking skills.

Aho (2011) defines computational thinking as thought processes that are involved in formulating problems in such a way that the solutions can be presented as computational steps and algorithms. Concretely, computational thinking means applying tools and techniques to understand, reason and solve problems in relation to both natural and artificial systems and processes (Denning, 2007), developing general-purpose thinking and design skills (Wing, 2006), and mental tools (Tedre & Denning, 2016). Educators have been confused by the multiple definitions of computational thinking (see Tedre & Denning, 2016) and subtle distinctions between computational thinking and programming (Barr & Stephenson, 2011). Viewing computational thinking as planning, learning and scheduling in the presence of uncertainty (Wing, 2006) may disclose the broad relevance of computational thinking for many other areas of the curriculum and for life in general (Webb et al., 2017). In this regard, as Wing (2006) has introduced, computational thinking is a kind of problem solving and a readiness to move between different levels of abstraction and decomposition, transformation and simulation. In other words, computational thinking means thinking recursively and choosing the appropriate representation for a problem or modelling a problem to make it tractable.

Barr and Stephenson (2011) have suggested that programming provides a transparent way of developing computational thinking. Nonetheless, Tedre and Denning (2016) note that coding cannot be accepted as the aim of computational thinking because coding as a part of the program-construction process does not require the highest level of computational thinking. Bellettini et al. (2014) have also warned that if the focus is only on coding or on using computer applications with ready-to-use recipes, there will not be enough space for a deeper understanding and creativity. Coding skills are, according to Tedre and Denning (2016), increasingly less important when what is actually more relevant is the ability to deal with design challenges and handle design tools. In this way, computational thinking provides insights into many areas of everyday life and into a wide range of disciplines (Wing, 2006). In this regard, despite that the terms computational thinking and programming as well as programming and coding are sometimes used interchangeably, in this study we do not see them as synonyms. We see computational thinking as a person’s analytical ability to formulate and solve problems, to design and implement ideas and to address those problems. In turn, programming is seen as the process of designing and building an executable computer program for accomplishing a specific computing task, after which the practical implementation of these solutions is concretized by coding (i.e. actions using some programming language).

To introduce computational thinking into schools, computer science standards have been defined (Computer Science Teachers Association [CSTA], 2011; Computing at School [CAS], 2018) and curriculum guidelines have been prepared by many educational governing bodies around the world (Tedre & Denning, 2016). In practice, however, after having agreed what should be taught in terms of computational thinking (Mannila et al., 2014), the learning objectives are also noted as being difficult to meet, as teachers experience that they do not have enough knowledge and there is an expectation that it always means the use of computer applications (Caspersen & Kölling, 2009; Bellettini et al., 2014; Isayama, Ishiyama, Relator & Yamazaki, 2016). Several studies (e.g., Derus & Ali, 2012; Piteira & Costa, 2013) have reported that students at all levels of education have difficulties with the first steps when learning to program. Students have orientation difficulties and lack the skills to analyse problems. It has been suggested that an effective way to learn hierarchical skills such as programming should be to begin with real-world problems and with learning the lower level skills first, then progressing upwards (Derus & Ali, 2012). Thus, Webb et al. (2017) have recommended using a spiral approach when implementing computational thinking in education: First, by problem solving using concrete meaningful objects to discover concepts, second by practising computational thinking about the objects and concepts to create algorithms and solutions, and third, by programming.

According to Ertmer and Ottenbreit-Leftwich (2013), despite most teachers having shifted away from implementation technology being about learning about technology as a subject, technology is still primarily used as a delivery tool, thus reinforcing old ways of learning. They argue that the teachers' traditional teaching beliefs are the primary reason behind neglecting the use of technology as a form of learning with technology as a cognitive partner (Jonassen, 1996). Several studies have noted that teachers, in general, need direct guidance and advice with concrete examples to expand their technology-based pedagogical knowledge, but also to put it into action in their practices (Bell, Rosamond, & Casey, 2012).

Barr and Stephenson (2011) have described examples in maths, science, social science and language for teachers to help them to identify core computational thinking concepts and capabilities. Several projects with simulation and modelling, robotics, or computer game design have been shared to support teaching computational thinking (e.g., Hutch, 2007; Bell et al., 2012; Foerster, 2016; Merkouris, Chorianopoulos, & Kameas, 2017). Webb et al. (2017) have proposed that computational thinking and abstract symbolic manipulations can be presented in a very concrete way and without starting with computers. However, according to Pellegrino and Hilton (2012), the teacher ought to develop a new understanding of the subjects that they are teaching before implementing computational thinking and programming more widely. Consequently, they should see where and how computational thinking already exists naturally and how it can be implemented to create real and virtual artefacts (Barr & Stephenson, 2011).

According to DeNicola (2016), programming has features that are relevant to crafts. Programming as a digital craft is quite well recognised in computer science (Tedre, 2018) but, in practice, it is not introduced in the same way with the theoretical concepts of crafts. Conversely, there is no comprehensive review that examines the unconscious aspects associated with teaching programming in crafts despite there being an increasing number of studies and more literature dealing with technology education in crafts. Thereby, the aim of this systematic literature review is to provide answers to the following research questions:

1) How is programming described through the craft science-based concepts of craft labour?

2) What kinds of examples are presented to teach programming in crafts during basic education?

We begin with a review of craft education in Finland where programming has been included in craft education in the National Core Curriculum for Basic Education (Finnish National Board of Education [FNBE], 2014) and where craft is based on multi-materiality and design-based holistic craft processes. This positions the paper within the existing literature and helps to deepen the theoretical nature of this review.

Craft education: The Finnish case

In Finland, the new National Core Curriculum for Basic Education (FNBE, 2014) has integrated technology into its national K-9 and K-12 curricula as a cross-curricular topic integrated into all subjects. The terms used in the curriculum are computational and algorithmic thinking, programming and ICT (information and communication technology) competence, which encompass a wide array of ICT-related skills (Kwon & Schroderus, 2017). Programming is integrated into crafts from the third grade onwards. Notably, there is an aim to increase the teaching of computational thinking to develop children's analytical abilities and through processes that also develop algorithmic thinking as a problem-solving strategy. More concretely, the ICT-related skills refer to the problem-solving process (i.e., programming) for accomplishing a specific computing task by using a programming language (i.e. coding, e.g., using Scratch). ICT competence means also responsible and safe use of ICT in communication and networking.

In Finland, craft is a combined single subject for all students in basic education (FNBE, 2014). As a school subject it has similarities with the design and technology education (D&T) and technology education in other countries. Finnish craft classes could also be considered as craft, design and technology education in international comparisons (Porko-Hudd, Pöllänen & Lindfors, 2018). Craft is a compulsory subject of two hours a week for all students from first grade to seventh grade. After seventh grade, it is optional. The curriculum discusses design-based holistic and multi-material craft, which includes technical work and textile work. It has its own objectives, but it is supposed to be implemented as open themes and with a holistic interdisciplinary approach. The self-expressive design and technology-based activities in crafts are required to be investigative, explanatory and experimental, and should be carried out by employing various visual, material, technical and manufacturing solutions. The students are also assumed to be able to utilise new technology and document their craft processes using ICT.

Craft is oriented to integrate design and skilled creative work with new technology (FNBE, 2014). Thereby, in multi-material craftwork, students are supposed to make tangible products through technical machines, devices, materials and systems that people encounter every day. The possibility of informing computational form-finding processes via the physical act of making serves as a point of departure for examining the relationship between material, procedure and form (Pöllänen & Urdziņa-Deruma, 2017). As McCullough (1996) has noted, hands help in acquiring knowledge of the world, of complex systems, concretely.

The craft process itself focuses on design, problem solving, understanding the restrictions, choices and possible defects, data collection and analysis across disciplines, and identifying and evaluating possible solutions (Pöllänen, 2009). This means generating a strategy and a sequence of orders (like an algorithm), implementing designs, and continuously evaluating the solutions by testing and debugging missteps, and modelling and running trial runs or simulations in order to formulate the solution into a prototype or an artefact (Anttila, 1993). In holistic crafts, reflecting and communicating in all phases of the process help in moving between levels of abstraction and help with innovation and exploration in order to design and manufacture artefacts. The holistic craft process refers to the thought processes and embodied thinking required to analyse the prerequisites and effectively solve a specific problem while articulating and formulating it, creating an expression of the solution and analysing the outcomes that are also the core of computational thinking or algorithmic thinking (Pöllänen & Urdziņa-Deruma, 2017; cf. Kwon & Schroderus, 2017).

Methodology

Our methodological option in this qualitative study is developed based on pragmatism (Gutek, 2014) and a systematic literature review (Miles, Huberman, & Saldana, 2013). After defining our research question, we followed the steps of the systematic literature review process: We determined the required characteristics of primary studies, we retrieved the sample of potentially relevant literature and, thereafter, we selected the pertinent literature and synthesised it in order to be able to report the results (Durach, Kembro, & Wieland, 2017).

We started the systematic review by searching the papers that focused on programming and craft. For the first research question concerning programming as a craft, two kinds of publications were chosen: At first, eight discretionary selected publications on craft science (in which the craft process as craft labour was described with scientific concepts) were chosen to act as background literature. Thereafter, to contextualise the study, publications describing the process of programming were screened through Google search: 524,000 results were found in 0.40 seconds. Google Scholar produced 3.67 million results. Consequently, the same concepts were used to find more limited results through the Finnish National Library Service (FINNA), which resulted in 507 hits. For this study, ten publications were chosen as the main data for the first research question based on the following inclusion criteria:

1. The paper focused on programming and coding and its title contained the words 'craft', 'craftsmanship', 'craft process', or 'programming process'; and
2. The study was written in English.

For the second research question, to seek examples to teach programming in crafts in basic education, the literature review was not initially limited to anything (see Rodgers, 1993). At first, a search for the programming and crafting concepts through Google search produced 11.5 million results in 0.48 seconds. Among the search items there were practical tips, advice and tools. Therefore, these had to be excluded, even though the philosophical viewpoint in this review was pragmatic. Pairing the two concepts – programming and crafting – in Google Scholar still resulted in 43,200 hits. Focusing the concept of programming to 'computational thinking' and pairing it to crafts gave 1890 results in FINNA. For this study, 68 research papers, book chapters and conference papers were finally chosen on the strength of their titles – which either referred to craft and programming or to craft and learning technology – and these acted as the main data for the research question. Thereafter, we read the full texts by weighing up their content in terms of the inclusion criteria to verify selection.

To answer to the first research question, we focused on the descriptions of the programming process and on the similarities of the craft process described in the craft science literature. Thus, we reflected the main characteristics of the programming process through the craft science-based concepts of craft labour. Thereafter, to find examples relating to teaching programming in crafts in basic education, we read the full texts, itemising the widest variety of opportunities that combined programming with crafts (both for textiles and for technical work).

To avoid bias, we tried to capture all of the relevant papers to get a representative literature base for this study (see McGowan & Sampson, 2005). Thus, the final search was done through FINNA as it contained a wide range of databases managed by Finnish universities where the search for international scientific reviewed articles could be carried out. To avoid selection bias (Felson, 1992), the inclusion criteria were carefully considered from the perspective of computer science and craft science. Therefore, the related programming concepts (coding, computational thinking, technology) and craft (crafting, crafts, different techniques and materials in crafting e.g., weaving, e-textiles, robotics) were also taken into account while searching the relevant literature. The advantage of this approach is that both disciplines are represented, allowing for the possibility of discussing the related concepts. According to Schlosser, Wendt and Sigafoos (2007), expectancy bias may be reduced by engaging several researchers from a variety of sociocultural and educational backgrounds. It is hoped that the review results will offer more than a mere description of the existing literature, instead offering frameworks for nuanced scientific and subject boundaries at school.

Research results

The purpose of this study was to view descriptions of programming through the craft science-based concepts of craft labour and, thereafter, to seek examples to enable teaching programming in craft education. Thereby, the results initially present how programming is described as a craft. Thereafter, we introduce different examples of how technology and programming and, in particular, computational thinking can be taught in crafts.

Programming as a craft

Sennett (2008) has written about software as a modern craft, and Hansen, NørGård and Halskov (2014) have written about programmes as a digital craft, with Kaijima and Michalatos (2008) focusing on software as a craft. Additionally, Lindell (2014) has described code as design material that allows the metaphor of craft to be used for the activity of programming. Programming has also been called material crafting practice (McBreen, 2002; Martin, 2008) and designing and building (Tedre, 2018). More clearly, DeNicola (2016) has used craft-related concepts while talking about modern-day software, programming processes and programmers as digital artisans. He has linked them to concepts of materiality, aesthetics and embodiment. All these descriptions view programming as involving concepts that are also linked in craft science to craft such as creativeness, the ability to make aesthetic judgments, ethical considerations, iterative design, contingency planning, holisticity, refinement and reflection (Ihatsu, 2002).

Craftsmanship brings with it a metaphor of the skilled practitioner who is intent on mastering programming as a craft with pride and responsibility (McBreen, 2002). The programming process (Caspersen & Kölling, 2009; Webb et al., 2017) involves systematic executable steps to get a solution to a problem. This means that, like a craft process (Anttila, 1993), the process of programming is opposite to that of mechanical production (Lindell, 2014) and industrially produced artefacts (DeNicola, 2016). Craft contains the whole design and making process, where hand-controlled machines are used, and the activity is directed by thinking (Anttila, 1993). According to Ihatsu (2002), craft includes both the idea of the product, the product itself and the know-how for its realisation. The craft process can be understood not only as a way of making things by hand, but also as a way of thinking through the hand by manipulating a material as a means for logically thinking, learning and understanding through one's senses (Gray & Burnett, 2009). This kind of definition means that craft is a way of thinking through practices of all kinds (Adamson, 2007) and is one way of thinking intellectually (Sennett, 2008).

Just as Sennett (2008) described craft, Martin (2008) has also characterised programming with objective standards, striving for quality, having a sense of excellence, but also experiencing competitive pressure and frustration that comes from doing one's best. Hansen et al. (2014) have found in their study that coders' attitudes, when engaged in creative and expressive programming, had similarities to the relationship that craftsman had with their craft. In the same vein, the manufacturing metaphor and the concept of software as a product and as a beautiful articulation of a design (Martin, 2008) indicate that craft-based design and the processes involved are the key aspect, not the static endpoint (Ihatsu, 2002). Hansen et al. (2014) have noticed that the design and use of computer technology was conceptualised as craft engagement, craftsman rhythm and craftsmanship expressivity. Through persistent interaction with the material, the coder worked as a craftsman who immersed herself or himself in the form-giving activity. Implications of the programmers' activities as a craft means understanding materiality more than physical substance (Anttila, 1993), while hardware and software can be seen as manufactured things or objects of care with material aspects (DeNicola, 2016).

Programming is not only a mental exercise, as it is an embodied cognitive process that starts with our hands (Sennett, 2008). Thus, the programmer attains intimate knowledge of the potentials and limitations of the (raw)materials and technologies like a craft maker or designer does for aesthetic expression (Dormer, 1997). Material consciousness requires prolonged engagement, practice and patience with the work in crafts, where the constraints of the technology and materials slowly hone the worker's skills (Nimkulrat, 2012). This means that the programmer must gain the knowledge of the principles, patterns, practices and heuristics involved, just like a craftsman must do, so that the knowledge leads to the fingers and eyes (Martin, 2008). This is justified, as DeNicola (2016) has claimed that programming is shaped by material considerations that demand a sensitivity to aesthetics and entail embodied practice as a craft.

Computational thinking in crafts

The results of this study show how, for example, robotics and automation, microcontrollers, 3D modelling, prototyping, applications for documentation, visualisation, share-out and storytelling via multiple channels may help to build computational thinking-based learning experiences by using technology and programming in crafts. Thereby, crafts may help to teach computation, authentic computer science concepts (Angeli et al., 2016) as well as design and the basics of technology (Tedre & Denning, 2016) before the students are asked to code.

However, it is notable that, for example, the process of knitting itself has inherently procedural and computational aspects through knitting-pattern conventions and basic programming concepts (Craig, Petersen, & Petersen, 2012). In addition, weaving, crocheting and cross-stitching are intentionally models of mathematical designs and simplified programming language with code (see Eisenberg, 2002; Buechley, Eisenberg, Catchen, & Crockett, 2008). Practising in lower classes first with a pen and paper, and editing digital images, and making digital drawings and designs and programming may also help later with learning to visualise algorithms (Glenn & Larsen, 2012).

Programming could be practised in crafts, for example, in robotics and automation, and embedded systems can be used in the design and making the products (Nykänen & Lindh, 2012). Embodied target platforms such as robotics are noted as serving as motivators when learning building, programming and commanding (Blauvelt, Wrensch, & Eisenberg, 2000; Qi, Huang, & Paradiso, 2015; Merkouris et al., 2017), because the algorithms and programs are reified in concrete objects and not just as virtual characters on screen (Armoni, Meerbaum-Salant, & Ben-Ari, 2015). Today, there are several robotic technologies and educational robotics toolkits teaching programming and engineering concepts, for example, from LEGO (Mindstorms EV 3, WeDo) and VEX robotics (VEX EDR, VEX IQ). Thus, children can construct robots, conduct scientific experimentations, measure and log environmental data, create controllers and even build interactive art installations with microcontroller-based devices (e.g., GoGo Board). These constructions may enable the creation and programming of artistic works involving motion, light, sound and music (Rusk, Resnick, Berg, & Pezalla-Granlund, 2008).

The arrival of recent materials such as conductive fibres and threads, combined with accessible embedded computing platforms, have made it possible to combine microcontrollers with craft materials and processes (Mellis, Jacoby, Buechley, Perner-Wilson, & Qi, 2013) to build, for example, computationally enriched paperworks and textiles (Katterfeldt, Dittert, & Schelhowe, 2009; Kafai, Fields, & Searle, 2014). For example, open-source-based fabric-based construction kits with sewable microcontrollers, e-textiles, have enabled even beginners in crafts to design and build their own soft wearables (e.g., scarves, light-up T-shirts) and other artefacts (e.g., soft toys, jewels and other decorative items) with different kinds of materials and techniques, and with light and sound (Buechley et al., 2008; Rusk et al., 2008; Buechley & Hill, 2010; Peppler & Glosson, 2012; Weibert, Aal, von Rekowski, & Wulf, 2015). Sewable electronic components can be attached to fabric and connected to another with conductive thread, after which the completed circuit can be hooked up to a computer and programmed (Searle & Kafai, 2015). Students may, for example, in an open learning task, create an interactive garden with a wide variety of materials (Rusk et al., 2008; Millner & Baafi, 2011), or sew crafted stitches with conductive thread to create a binary pattern above and below the fabric surface, where the strobe light may mimic the created pattern (Tan, Keune, & Peppler, 2017). Microcontroller boards and toolkits (e.g., Micro:bit, The Circuit Playground, Maker Toolkit, Maker App, App Lab) with minimal software installation and wide platform compatibility allow the students to quickly build apps that communicate with external hardware. Virtual reality (VR) environments and applications are constantly improved and thus, students may use the virtual realm while designing, prototyping and simulating prior to their own making and construction process (Kauhanen et al., 2017).

Novel technologies and materials, and digital design tools, for example, with modelling, scanning and prototyping, and 3D printing have also become prevalent in craft and design (Goodman & Rosner, 2011; Weiler & Kuznetsov, 2017). Digital fabrication devices such as laser cutters and computer-controlled embroidery machines (Bucheley & Hill, 2010) enable the crafter to stay in the material realm while using technology in crafting. Students can use applications for design, electronics and programming, and simulate their artefact on a prototyping platform as well as see and present it in interactive animations (e.g., Tinkercad, Sketch.up, Proto.io, Prott). In becoming increasingly common, 3D printing methods create easy ways in which to personalise the fabrication of crafting colour 3D artefacts (Weiler & Kuznetsov, 2017) or to use 3D conveyor cutting and image-transfer techniques together in the same artefact. Crafts may also be integrated with mathematical subjects (Foerster, 2016) such as in computational crafts used in the design and construction of mathematical model sculptures made from paper (Eisenberg, 2002).

Technology may offer creative and facilitating opportunities for design and craft to visualise and manufacture designed objects, for example, a knitting visualiser connects knitting and code (Yang, 2017), and weaving as a traditional technology to make products by hand can be customised with computational tools, rapid prototyping, 3D and computer-aided weaving (Tao et al., 2016). Computer-aided design and computational tools that enable two-dimensional (2D) patterns to be viewed in 3D, or vice versa, 3D designs to be obtained as 2D patterns, will give technology-based examples alongside traditional methods in crafting (Martin, 2015; Tao et al., 2016). Additionally, 3D body-scanner programs and styling simulators may introduce computer-based schematic systems to design education (Pursiainen, 2011). Revitalising craft culture as digital craft even helps to proliferate up-to-date crafting and rare handicraft techniques (Goodman & Rosner, 2011), for example, like the ancient marbling technique that uses flowing patterns of paint directly on the surface of water that are then captured on paper, which may now be made by using digitally controllable electromagnets (Nitsche, Quitmeyer, Farina, Zwaan, & Nam, 2014).

Several applications for documentation, and image and video tools make students' designs, crafted artefacts and crafting processes visible with texts, photos and videos. Students can visualise, share and co-develop their designs in collaboration, and make interactive presentations and portfolios (e.g., Onenote, Book Creator, Microsoft Sway). In addition, QR codes or linking applications (e.g., Thinglink) may be used in a new way in crafts where students can create their own codes with a generator that helps to record the student's craft process in illustrated steps (Jaatinen, Ketamo, & Lindfors, 2017). Mobile applications for smartphones aid craft processes to become multimodal stories with documentation, communication and instruction for a process-based workflow (Wiklund-Engblom, Hartvik, Hiltunen, Johansson, & Porko-Hudd, 2015).

Recently, many museums and archives have allowed their materials to be used, for example, FINNA is a service for the exploitation of the cultural heritage having an application for a programming interface to be used for one's own applications. Social media has helped designers, artists, programmers and educators to collaborate and to show how openly available materials on the Internet can be reused in creative ways (see http://hack4.fi/2015-2/hackathon/projects/). Transparency is promoted by a creative common licence where anyone can be associated with their own output. This role played by open materials, technology, digital resources, and design with computers and mobile software also suggests a transition from purely physical to digital practices in crafts (Rosner, 2010).

Fernaeus, Murer, Tsaknaki and Belenguer (2014) have found that students use materials creatively and productively in interdisciplinary projects that combine craft and natural materials, mechanical parts and programmable devices. Thereby, the students created and learned through hands-on activities about the role of materials in the design process, but they also learned how to make the artefacts and accessories interactive. This inspired both girls and boys and working in teams. Katterfeldt et al. (2009) have noticed that through the computation construction activities, students became more self-confident in dealing with technology and were able to draw relations between their own creations and technologies present in their environment. In the same vein, Blikstein (2013) has noted that students felt proud when working with computer-controlled tools. Eisenberg (2002) has insisted that craft activities have both intellectual and emotional affordances that are usually relatively lacking in computer-based education. Accordingly, creative hands-on experiences in a familiar setting have helped in overcoming misconceptions about computation (Pollock, McCoy, Carberry, Hundigopal, & You, 2004).

Conclusion

It seems that parallels between programming and crafting are convincing. Viewing computational thinking as craft with problem solving and design, and a readiness to move between different levels of abstraction and decomposition, transformation and simulation (see Pöllänen & Urdziņa-Deruma, 2017; cf. Wing, 2006; Kwon & Schroderus, 2017) may help in selecting appropriate representations and achievements for tractable hands-on activities to concretise programming in basic education. Computationally-enhanced craft education can integrate the physical and virtual worlds, generating different artefacts and engaging different skills and the use of them in creative ways (Wood, Rust, & Horne, 2009). Consequently, novel output devices and different kinds of materials may construct new domains of technology with a combination of crafts and computation that can render both activities even more valuable (Blauvelt et al., 2000; Mellis et al., 2013; Kafai et al., 2014).

It seems that ICT offers the opportunity to use different learning materials, learning platforms, drawing programs, editing digital images and making drawings, videos and designs to support students' own innovations and designs in crafts. A media-rich software development environment for novices with an emphasis on an iconic style of programming may serve as a motivating pedagogical instrument that helps foster computational thinking and forms a precursor for programming activities (Resnick et al., 2009; see Armoni et al., 2015). Technology and programming may shift the focus in craft education to the design and use of different materials, tools and technologies to create new knowledge for solving complex problems. The findings show that by connecting craft education to modelling, visualisation, simulation and printing, and to new materials and applications combined with accessible embedded computing platforms, the students may learn craftsmanship-based actions and the basis for computational thinking in different kinds of authentic technology-based projects.

Blikstein (2013) has found that students were delighted when working with computer-controlled tools as they could make products that look good and, compared to hand-crafted objects, the process was easy and fast. Yet, making multiple identical or nearly identical items does not meet the criteria of a design-based holistic craft process, nor does it develop the skills of craftsmanship and computational thinking. When copying and using computer applications with ready-to-use recipes, there will not be enough space for deeper understanding and creativity (Bellettini et al., 2014). Technology ought to be implemented in such a way that it boosts students' problem-solving and thinking skills, as in a design-based craft process (Pöllänen, 2009), avoiding ready-made lessons with step-by-step, recipe-like models, and enabling learning through technology as a cognitive partner (see Jonassen, 1996; Resnick & Rosenbaum, 2013). Thus, it is not enough to programme a robotic toy to move as desired, to focus attention on the laboratory equipment, or to view crafts as routine-based craft making (see Pöllänen & Urdziņa-Deruma, 2017).

According to Martin (2015), the risk of a tool-centric technology-based approach is the neglect of the multifaceted understanding of design-based making and the real mindset of the making by hand. In turn, designing, creating and programming in crafts may allow for the creation of personally meaningful projects (Katterfeldt et al., 2009). Enabling students to design and program artistic creations that integrate, for example, light, sound, music and motion may expand the way in which technology, computational thinking and physical computing can be introduced in future-based educational settings. Programming must relate to the real world and especially to the students' interests and thoughts to overcome the initial difficulties in learning to program (Katterfeldt et al., 2009; Armoni et al., 2015) as well as gender-based attitudes towards technology (Hutch, 2007; Merkouris et al., 2017).

Clearly, design-based holistic and multi-material craft projects with playful hands-on learning experiences and abstractions with modelling, visualisation, simulation, printing, automation, robotics and programming can be used to teach computational thinking in crafts. The projects can be designed to start with an easy level first to familiarise students with the concepts with tips to solve questions, and then progress in difficulty with interesting themes and graphical programming to facilitate the transition to the more abstract representational style of programming languages (see Rusk et al., 2008; Isayama et al., 2016; Merkouris et al., 2017). Generic interactive programming platforms (Quinson & Oster, 2015) enable teachers to create specific programming microworlds that are adaptable to the goals of learning.

The presented findings describe that contemporary multi-material and design-based holistic craft may encompass different forms of technology and may thus help students to learn computational thinking by starting with design and practical problems and proceeding to technology-mediated programming skills (see Tedre, 2018). Thus, it is hoped that teachers see computational thinking more from a holistic perspective as a practice and through working with different kinds of materials. More widely, despite the case being based on Finland's experience, we hope that the findings will give theoretical perspectives for practitioners and policymakers to see the mutual benefit of the integration of crafts, design, technology and computation in basic education.

Acknowledgments

The project is supported by the Ministry of Education and Culture, Finland (Grant No. 50185-OKM/INNOKOMP 2017-2019).

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An Instructional Model for Social Design Education: A Design Project for Stray Animals Including Production-Based Learning Approach

H. Güçlü Yavuzcan, Gazi University, Turkey

Damla Şahin, Gazi University, Turkey

Barış Gür, Venn Design Ltd, Turkey

Özden Sevgül, Gazi University, Turkey

Cemil Yavuz, Gazi University, Turkey

Abstract

Social design education has become a significant part of industrial design education, thus new methodologies are required and being developed. One of these societal problems is animal welfare and human interaction with stray animals that is not a common topic amongst previous studies. This study presents a toolkit for social design teaching, combining social design thinking and product development processes to generate and realise design solutions for stray animals with a production-based learning approach. The toolkit consisting of nine phases under two processes was implemented into the second-year 'Product Design II' 7-week studio project at Gazi University. A total of 35 sophomores taking the course offered during the second semester of the 2017/2018 academic year, participated in housing and feeding stations for a stray animals design project. To analyse the appropriateness of the toolkit, the submissions and process of the project were observed and evaluated by instructors and post-project questionnaires were employed to both instructors and students. The results revealed that this toolkit for social design education combining design thinking and product development processes improved industrial design students' competencies and learning outcomes.

Key words

social design, design education, teaching toolkit, animal welfare, production-based learning

Introduction

The traditional definition of industrial designer as a creative genius or stylist has been changed since Ulm School's scientific approach in design and World Design Organization's (WDO) and Industrial Designers Society of America's (IDSA) new designer definition (IDSA, 2018; Roth, 1999; WDO, 2015). Industrial designers now are perceived as problem solvers and value creators through developing a deep comprehension of user need to design not only products but also systems, services, and experiences (IDSA, 2018; NASAD, 2017-2018; NCSU, 2018; NJIT, 2018; WDO, 2015).

Comprehending user needs is no longer limited with needs of one user or a group of users, there is an emphasis on needs of society as a whole, the impact of design on society as a component of a system. The values that designers create are economic, social and environmental (ASU, 2018; WDO, 2015).

Since the publication of Papanek (1972), Design for the Real World, drawing attention to the impact of design on the environment and society, "social design" has begun to be a widely discussed term in the field of design research. Papanek (1995) argued that the design profession serves consumer society and capitalism. He supported that designers should use their professional skills for addressing and solving social problems, as well. Similarly, Manzini's (2014; 2015) social design examples such as carpooling and community garden summarize that social design should meet social needs holistically without focusing only on financial profit.

As it was realized that design and designers could significantly influence the development and transformation of society, a variety of methods and models are discussed teaching social design in design education. Margolin & Margolin (2002) argue that social design could not be learned by conventional methodologies like design for the market. Instead, they suggest a "social model" that indicates the ways product design could meet social and environmental needs.

Based on this interest in social design, although there are few, some design schools or institutes included social design issues in their curricula or in their projects. It is seen that animal needs are generally ignored; only a few design schools incorporate animal welfare into social design issues, one of them is Delft Design for Values Institute (TUDelft, 2018). Although there is an increasing sensibility to animal welfare, the research on design for animals is limited and generally emerged last decade. There are some 3D printed prosthesis projects collaborated with veterinary doctors, product design departments, and non-profit organizations to save and improve animals' lives. Some leading international design competitions, A-Design Awards, IF Design Awards, The International Design Awards (IDA) and Red Dot Design Award included product design category for animals (A-Design Awards, 2018; IDA, 2018; IF Design Awards, 2018; Red Dot Design Award, 2018)

Since social design education has become essential in design education, it is necessary to develop new methodologies in design schools. Having examined the content of social design programmes and courses, it is seen that they mainly focus on cross-disciplinarity, co-creation, practice-based learning approaches, combining theory and praxis. It is supported that social design could just be learned by practise-based studios (Heller, 2018). Besides, studies on learning styles of design students indicated that industrial design (ID) students learn better and prefer learning by experiencing, thinking, doing and/or reflecting (Durling, Cross, & Johnson, 1996; Willcoxson & Prosser, 1996). With producing, testing and analysing the full-scale prototyped products for the real world, ID students can learn better whether their project has any problem or not in terms of materials they selected, mechanisms they used, production methods they decided on (Greenberg, 2017; Margolin, 1991; Margolin & Margolin, 2002). Practise-based learning also increases ID students' entrepreneurial skills like creativity, innovativeness, motivation; business skills like communication and project management and technical skills like tools and materials production, calibration, testing and revision (Ganefri, 2013).

There is limited research about production-based learning in social design education of industrial design students. The existing ones, as mentioned above, emphasize that social design education requires a practices-based, experiential or production-based learning approach. However, these limited research projects lack empirical findings to prove the claim that learning by producing is a necessity in social design education. Therefore, the objective of this study is to present a new toolkit for social design teaching and conducting applied research to observe the effects of the toolkit on education. The presented toolkit combines social design thinking and product development processes to generate and realise design solutions for real-world problems with production-based learning approach and co-designing practices. To achieve this, a toolkit for social design learning, consisting of nine phases under two processes, was implemented into the second-year 'Product Design II' 7-week studio project at Gazi University. The evaluation of the project consisted of an analysis of the submissions and process observations of instructors and post-project questionnaires completed by both students and instructors.

Social Design in Design Education

The terms, social design, socially responsible design, and socially oriented design, are buzzwords and have gained significance in design research in recent years (Melles, de Vere, & Misic, 2011; Tromp, Hekkert, & Verbeek, 2011). Indeed, there is a long history behind social design beginning with the ecological movement in the 1960s and design movements against consumerist society in the 1970s and 80s (Whiteley, 1993).

Undoubtedly, the publication of Papanek (1972), Design for the Real World, introducing the idea of the 'Third World' was the turning point for social design issues. The main characteristic of the book widely accepted is being against consumerism and supporter of the notion that designers should be more responsible in their design professions (Clarke, 2013). Papanek (1985; 1995) criticizes the design profession due to its potential in supporting consumerist society and capitalism. Papanek emphasizes the prominence that designers should focus on design for non-profit and canalise their skills to solving societal problems in the manner of an anti-consumerist approach. Industrial designers should not be limited only to serving companies and increasing their profits, they are expected to take social responsibilities by creating non-profit products for disabled, homeless, older, unemployed people, or for third world countries (Papanek, 1985; Whiteley, 1993; Davey et al., 2003).

Likewise, Manzini (2015), one of the newest theorists in the field of social design research, suggests that social design is not new; it is just a new way of contemporary design (p. 55). Manzini identifies social design as "new products, services, and models that simultaneously meet social needs and create new social relationships or collaborations". Manzini (2014; 2015) states that socially responsible design results in social innovation and it is a behaviour change, a new way of production and consumption bringing social justice.

Margolin & Margolin (2002) suggested a “social model” indicating the ways product design could satisfy people’s needs and improve the physical and social environment. The aim is not to put designers against each other, but reveal the opportunities of designers to collaborate with disciplines like education, health, crime prevention for complex social design problems.

As mentioned before, Papanek argues that the design profession only focuses on the market and selling. Although there is an increasing interest in social design, very few designers address social issues and design for social impact due to the current situation of product design education. Therefore, it is vital to develop new strategies in design schools for social design education. Design educators can provide students with opportunities to collaborate with non-profit organizations, institutions, and industries to solve social wicked problems in meaningful ways (Margolin, 1991; Margolin & Margolin, 2002; Manzini, 2015; Yang, 2015).

Having examined the leading design schools; it is observed that there are limited social design programmes and courses. Some of the design schools with social design programmes or courses are School of Visual Arts, Design Academy Eindhoven and Delft University of Technology (Delft University of Technology, 2018; Design Academy Eindhoven, 2018; School of Visual Arts, 2018) The common points of them are cross-disciplinarity, co-creation, practice-based learning approach combining theory and praxis.

Social Design and Animal Welfare

Definitions of social design generally are based on satisfying people needs. However, as human beings, we share our planet with animals as well as the natural surrounding and affect them in several ways. Although animal welfare is one of the concerns of social design, there is limited research addressing the needs of animals. The research about design for animals emerged last decade and mainly focuses on Animal-Computer Interaction (ACI) (Mancini, 2011; Ritvo & Allison, 2014; Väätäjä, 2014; French, Mancini, Sharp, 2015; Westerlaken & Gualeni, 2016; Hirskyj-Douglas & Read, 2016; Wirman & Zamansky, 2016). Animal-Computer Interaction was first introduced as an academic discipline included in Human-Computer in 2011 by Mancini based on three aims:

“(1) studying and theorising the interaction between animals and technology in naturalistic settings (2) developing user-centred technology to improve animal welfare, support animals in their activities and foster interspecies relationships, and (3) informing the development of user-centred approaches to the design of technology intended for animals, enabling them to participate in the design process as legitimate stakeholders and contributors.” (Mancini, Lawson, & Juhlin, 2017, p.131)

Production-Based Learning in Social Design Education

Recently, as mentioned in the previous section, social design has become important in design education. Current methodologies developed in design schools generally focus on markets and show less interest in non-profit projects for specific or minority populations.

Social design programmes or courses emphasize a practice-based learning approach combining theory and praxis. Founding Chair of the first MFA program in Design for Social Innovation at SVA, Cheryl Heller (2018) also declares that social design could just be learned by practise-based studios. Since social design issues are related to real-life problems, practice-based phases like prototyping and testing are crucial to solve these problems. Heller's idea is supported by other studies on practice-based or experiential learning methods in design education. Although different results exist about studies on learning styles of design students, a majority of studies support that design students are mainly diverger (concrete experience and reflective observation) and accommodator (concrete experience and abstract conceptualisation) according to Kolb's four-stage Experiential Learning Theory (Bender, 2004; Carmel-Gilfilen, 2012; Kolb & Wolfe, 1981; Nussbaumer & Guerin, 2000). Both prefer doing rather than thinking and practical learning rather than theoretical (Kolb, 1994).

Moreover, the research by Demirkan (2016) based on Felder-Soloman's Index of Learning Styles revealed that design students prefer a sensing learning style such as facts and concrete material rather than theories. It is also found that design students are active learners; they prefer teamwork and hands-on activities, like drawing and making a mock-up (Carmel-Gilfilen, 2012; Demirkan, 2016; Nussbaumer & Guerin, 2000).

Studies on production-based learning indicate that failure is the most powerful tool for learning and students can only experience the failures with experiments, prototypes, interactions and testing them. Without producing, testing and analysing ID students could not learn whether their projects have any problems or not (Gladysz & Santarek, 2014). In addition, the study of Ganefri (2013) supports that a production-based learning model increases learning outcomes.

ID students in design process deal with not only aesthetic values but also practical and functional values of the products. Thus, in the production-based learning model, full-scale, fully functional real-world prototyping is vital, especially in ID education. While making non-working prototypes, students make their material selection decision randomly. This prevents the students and instructors from evaluating the projects correctly. On the contrary, during full-scale prototyping, contacting with manufacturers, finding sources for real materials, production and assembly processes enable ID students to have full knowledge of materials, mechanisms and current industry trends (Gattis, 2002). Therefore, full-scale prototyping increases the efficacy of production-based learning model (Yamaçlı, Özen & Tokman, 2005).

As the above discussion attests, it can be concluded that a new methodology combining social design thinking process with production-based learning model including real final products to be achieved in social design education and contributing to students' technical and professional skills can be useful in design education.

Methodology – A Toolkit for Production-based Social Design Learning

Concerning the above discussions, a practise-based approach is essential for social design teaching to achieve realistic design solutions. Therefore, a new teaching toolkit for social design focused on production-based learning is created. The fundamental objective of this toolkit is to guide design students through a combination of social design thinking and product development processes to develop and realise design solutions for social problems with a practise-based learning style.

The toolkit is inspired from different design sources and methodologies, comprising *IDEO's Human-Centred Design (HCD) Toolkit* and *Design for Social Impact Toolkit* (2018), *FROG's Collective Action Toolkit* (2018), *ArtCenter College of Design's Design Strategy for Social Innovation: A Toolkit for Educators* (2018) and from instructors' own professional backgrounds and experiences in the field of design research. IDEO's HCD toolkit (2018) consists of some design phases just for design companies. ArtCenter College of Design's toolkit lacks phases about preparing social design brief and building teams. FROG's toolkit (2018) is missing phases like testing prototypes and optimization. Therefore, none of these toolkits are focused only on social design education. Thus, they are combined in a way that is suitable for the social design project that will be conducted and created a new teaching toolkit. This toolkit combining social design thinking and product development processes consists of nine phases: Preparing guideline, research, building teams, defining problems, idea generation, preliminary presentation, field testing, optimization and final presentation (Figure 1). The toolkit is fundamental for directing the students to new components like field research and co-creating with non-profit, and partner organizations and thus, it differs from traditional design processes used at Gazi University.

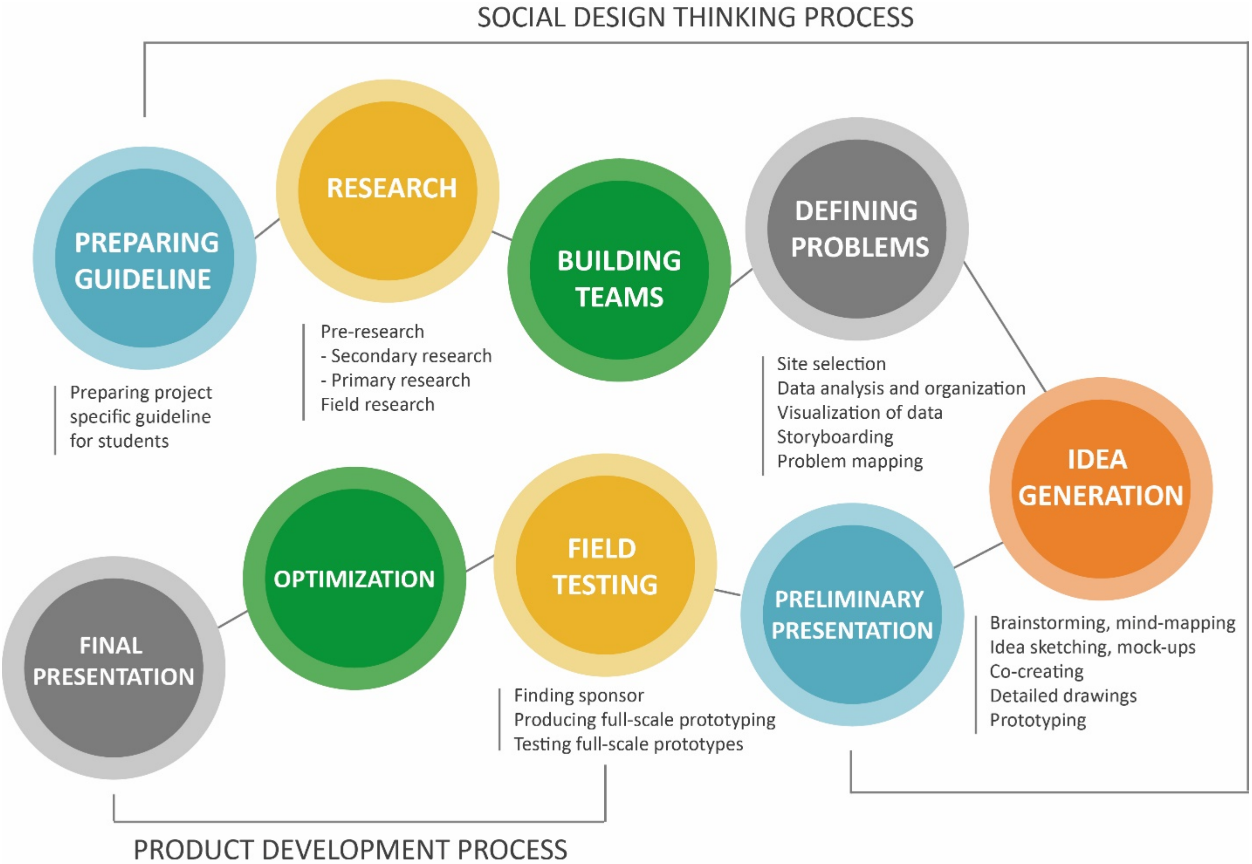

Figure 1. Phases of a new teaching toolkit for production-based social design

The Product Design Project: Housing and Feeding Stations for Stray Animals

Before building the design brief, different alternative design projects for design for animals were evaluated according to their suitability for the proposed social design toolkit, accessibility for students, and approximate duration. Taking account of these specifications, it was decided to assign housing and feeding stations for stray animals in Gazi University campuses as a product design project.

Details of the nine phases of the project combining social design thinking and product development process (as the outline is mentioned in Figure 1) are as follows:

Preparing a guideline for "Design of housing and feeding stations for stray animals"

In this phase, instructors prepared a guideline for "Design of housing and feeding stations for stray animals". This guideline consists of five freedoms of animal welfare developed by The Farm Animal Welfare Council (2009) and principles for design of animal shelters and feeding stations.

Five freedoms of animal welfare: Before designing animal shelters and feeding stations, it is vital to take into consideration the needs of the animals. The Farm Animal Welfare Council (2009) was developed "Five freedoms of animal welfare" describing both the needs of domesticated animals and duties of care owed to them. It is used around the world as a benchmark for the care of all animals in shelters too. The five principles are freedom from hunger and thirst, freedom from pain, injury, and disease, freedom from fear and distress, freedom from discomfort, and freedom to express normal behaviour.

Design of housing and feeding stations for stray animals

Site Selection: Before selecting sites for the shelters and feeding stations, instructions that should be followed are as follows:

- Identifying the population of stray dogs and cats that needed help in the area over the previous few years, and their behavioural situations whether they live individual or as a group.
- Researching existing situation about stray animals in the area, how they are cared for and by whom. (Local organizations or communities responsible)
- Analysing environmental conditions and geological structure and which materials could be recommended these conditions.
- Obtaining information from local organizations and people about proposed the shelters and feeding stations.

Research

Pre-research: Students were asked to research about stray animals in general. Students made interviews with pet owners, veterinarians, animal organizations and regular pedestrians nearby to understand both animal needs, and how human and animals interact, supported occasionally by online or printed written and visual resources.

Field Research: Students investigated separated campuses of Gazi University in terms of environmental conditions and geological specifications supported by contextual research. They identified the population of stray dogs and cats, observed their behavioural situations, whether they live individual or as a group and how they are cared by whom via interviewing non-profit organizations, community leaders and people caring stray animals in campuses.

At the end of this phase, students submitted and presented all written and visual research outputs and problem definitions revealed accordingly to the instructors.

Building Teams

A total of 35 ID sophomores attending a 'Product Design II' course participated in the project. The demographic makeup included 28 females and 7 males. Seven teams consisting of between three to five members were formed according to their research interests.

Defining Problems

Teams selected sites with respect to collected data from previous phases to continue their design process. They organized and analysed these data in order to define problems and to visualise them. In this phase, team members continued to collaborate and get feedback from stakeholders. They were asked to present their problem statements with storyboards and problem maps twice a week.

Idea Generation

Teams generated ideas considering their design problem statements by utilising creative design thinking techniques; brainstorming, mind-mapping, and design matrices. They presented their ideas with sketching and making mock-ups. In this phase, teams collaborated and co-designed with non-profit and partner organizations. They received feedback from instructors for their design ideas during studio critiques and developed three proposals.

Preliminary Presentation

In the preliminary presentation, teams were responsible to present their research reports, problems they defined and three design ideas by both visually and verbally to jury members with multidisciplinary backgrounds. Presentations included analysis of animals and sites with photographs, storyboards, technical drawings and a mock-up of the proposed product design. They suggested the materials that they will use in final real products. Jury members assessed the preliminary presentation for design thinking process according to four evaluation criteria that are coherency between research and decision-making, analysis-synthesis and problem defining, creativity and originality of the design proposals. At the end of each presentation, the jury eliminated two of the three proposals and teams proceeded to the next phase with the remaining one.

Field Testing

Teams searched for sponsorship. They presented their projects, preferred materials, and approximate costs to various organizations. When agreed, teams began to develop full-scale ready-to-use prototypes. Students benefited from opportunities of both university workshop and sponsor facilities offered. Prototypes were placed on site. Products were tested by dogs, cats, and people caring those stray animals. Students observed kennels and stations in use and they analysed their design in terms of user-product interaction, anthropometrics, and environmental suitability. Teams recorded all phases visually and presented during the course.

Optimization

Prototypes failed in various ways during field-testing. Revisions decided and students changed designs for optimization accordingly. Some of the prototypes were revised in the field, others sent back to the workshops. Teams repeated the optimization phase until designs were satisfactory in all terms.

Final Presentation

Teams presented their full-scale products on the field with a portfolio book including sketches, photographs and other studies made in the process. Products (shelters and feeding stations) were presented with the participation of stray dogs, cats, and caretakers in the final jury. Jury members consisting of instructors from multidisciplinary backgrounds, volunteers from non-profit organizations and employees of sponsor companies assessed designs according to 9 fundamental criteria which are explained below.

Evaluation of the Project

After the project is completed, 7 instructors of the 'Product Design Studio II' evaluated each project group by a set of scores. They individually reviewed the outputs, considering if the prototypes met the design criteria or not. Mean of these scores are announced as the project assessments, which will be shown in the results section of the study. However, as such scores lack providing qualitative findings, observations and questionnaires are preferred primarily.

Analysis of the submissions and process observations

Each instructor followed an assessment guide chart to give a score to the outputs. The guide includes 9 fundamental evaluations: Innovation, holistic design approach, coherency between project and process, engineering design, production quality, technical presentation, visual presentation, technical knowledge, and verbal presentation. Participant observation findings are collected in unconstructed group interviews of the 7 instructors. Visual materials are preferred to complement the observations.

The expected learning outcomes in each of the nine phases under two processes of the methodology that are the base of the process submission and observations were specified as follows:

Social Design Thinking

- Understanding the multiple social dimensions of product design and their relationships with real-world
- Researching, analysing and synthesizing competency about social design issues to develop realistic design solutions
- Collaborate and co-design with third parties (social institutions, non-profit organizations, etc.)
- Applying design thinking method to solve societal problems
- Discovering different creative methods and applying the suitable one for the design problem
- Communicating ideas and concepts via written, visual (drawing and mock-ups) and digital presentations effectively
- Comprehending dynamics of teamwork and being a productive member of a team

Product Development

- Understanding the basics of manufacturing processes and related materials, ergonomics and analysing costs.
- Understanding mechanical principles, devices and tools, and fundamentals of physics.
- Full-scale prototyping and realising design solutions for sustainable and positive social change
- Improving design skills (leadership, business communication, compatibility in teamwork, visual and verbal presentation, project management, design process, analysing environmental conditions, identifying user needs, field researching, cognitive skills, understanding design thinking process).
- Developing technical skills (understanding and applying the material, production techniques, anthropometrics, cost analysis)

Post-project questionnaire

Questionnaire completed by instructors: A questionnaire was asked to 7 instructors of the ‘Product Design Studio II’ to calculate the mean values of their subjective evaluations (project assessments).

Questionnaire completed by students: To get evaluative feedback about the effectiveness of the new teaching model, a 6-stage questionnaire was developed using a Likert scale. The post-project questionnaire was asked to 35 ID students after the final jury. 33 of them responded with valid answers and the other 2 did not participate.

Results

As mentioned before, 35 (28 female and 7 male) ID students of ‘Product Design II’ studio courses participated in the social design for the stray animal design project, resulting in 7 student teams. Considering that different design tasks are assigned to each group, various design problems occurred during research and product development stages. Thus, only the notable observations are presented group-by-group first. Later, the results of the questionnaire completed by students are displayed. Finally, the mean values of 9 fundamental assessment scores given by instructors are shown.

Findings of the observations

During the analysis of comments that instructors made during interviews, it is comprehended that evaluations can be divided into 3 phases. Research and design stage (1), prototyping and testing (2), application of final products in field conditions (3). Notable findings are explained below considering the mentioned phases in chronological order.

Team 2- Housing and Feeding Units for Multiple Dogs

The assignment of Team 2 is designing and producing doghouses and a feeding area for multiple stray dogs living as a group in one of the campuses. Students aimed to design seasonally transforming individual houses for each dog, according to their research findings. Students claimed that, in summer, dogs refuse to use houses as the heat rises, thus they begin to search for shadow areas in open spaces. Students also marked that even if the dogs prefer to roam and rest as groups, they also tend to need close yet individual spaces as they sleep. Feeding is also a group activity for these stray dogs, as the carers prefer to feed them in a scheduled order, according to the students. However, dogs are getting disturbed easily from each other during feeding. Thus, food for each dog should be separate and bowls should be placed with distance.

Students proposed designing modular houses with transforming blinds made from chipboard or MDF and glass or PMMA (transparent plastic sheet) first. Later they have decided concerning criticism, that transparency is not a constraint, as it also increases costs and causes shorter product life. Finally, they simplified their designs to be made only out of MDF (Figure 2). Students revised the structure and dimensions of the houses and developed a feeding unit as a part of the product-family, during the design stage of the course.

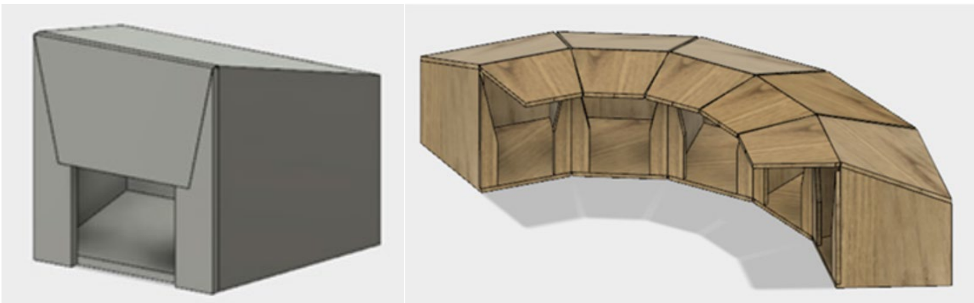

Figure 2. Team 2-Housing module design (left) assembly of the modules (right)

In the second phase (sponsorship and prototyping), their material decision has changed due to the donation of the wood-like composite material by the sponsor company. However, as the production technic is very similar, students could proceed to manufacture without a design revision. They managed the manufacturing of wall and roof plates for houses and cutting and welding of the profiles for the structure of the feeding station. Students struggled with an overweight of the kennels during shipment from atelier to the field. They also produced some of the missing parts in field conditions by themselves (Figure 3).

Figure 3. Members painting the sheets (left) and carrying the structure (right)

The Third phase (application of the final product) revealed a bunch of design or material related problems as well as some wise decisions. Preferring to use standard fences as tables for feeding bowls is advisable, as it is very cheap to outsource and prevents dirt piling. However, the bowls placed too close and not suitable to prevent dogs from disturbing each other, according to the comment of the carers. Students also missed checking the mass density of composite material comparing with the chipboard. Thus, when they needed to relocate the houses after the assembly, it was impossible to move the houses as the overweight made them need a pallet jack, which was not accessible. They also failed to apply a scissors mechanism for the blind, as they could only outsource improper OEMs. Hence, they had to change plan and fasten the supports permanently in open state. It is fair to discuss that problems that Team-2 experienced were quite educatory, as they had to disclaim some of the functions due to design mistakes and took decisions for solutions in times of crisis. Final products of Team-2 are displayed in Figure 4.

Figure 4. Team 2-Houses (left) and feeding units (right) for group of stray dogs

Team 3- Feeding Units for Multiple Dogs

It was aimed to provide more practical and long-term feeding solutions for stray dogs living on another campus. In the first phase, students observed the area and interviewed with carers. They also took opinions from nearby pedestrians. Students claimed that there is a need for storing large amounts of food to reduce the daily effort of feeding. They also suggested raising awareness by letting other students feed dogs easily by volunteering. Students proposed a combined storage unit design for both food and water with simple mechanisms, which can be activated by volunteering students or instructors (Figure 5).

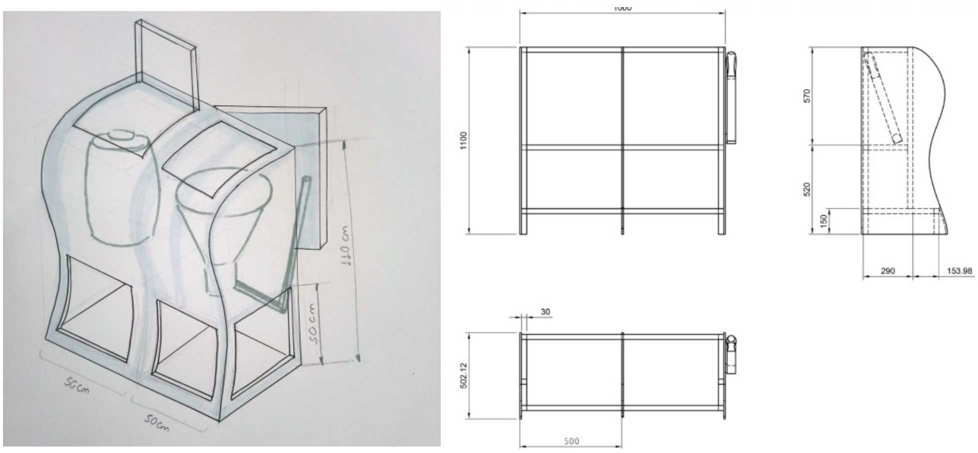

Figure 5. Team 3-Feeding unit sketches (left) and technical drawings (right)

In the second phase, they searched and found sponsorship for cutting, bending and welding steel profiles and sheets. However, after the production is completed they have faced that bowls are inaccessible for the larger dogs due to the low height of the ceiling, food supplying lid is not sealed well, which will cause moisture and rain to harm food and service gates are working hazardously improper. According to the criticism, students revised the prototype by their own (Figure 6), adding a roof, increasing the ceiling height by welding additional profiles and changing the assembling principles of the service gates. During these revisions, Team-3 faced that it is quite hard to revise welded steel products and miscalculating the anthropometrics and human-factor was a crucial mistake causing a lot of additional work. They also struggled hard to find aesthetically satisfying results as the revisions changed the design radically in an unexpected way.

Figure 6. Team 3-Cutting steel (left) impasting weldments and coating primer (right)

Similar to Team-2, also Team-3 made an advisable choice by outsourcing polypropylene containers that are chemical-resistant, providing hygienically better storing of food and water. Such decisions made students comprehend that outsourcing correct OEMs are also vital in product development. Phase 3 showed out that deciding to revise the design was very crucial, as in few days products faced rainy and stormy weather. During the course, Team-3 experienced that missing to satisfy major constraints could cause a lot of extra hard work. Images of the final product of Team-3 are displayed in Figure 7.

Figure 7. Team 3-Feeding Unit for Group of Stray Dogs

Team 5- Housing and Feeding Units for Multiple Cats

Team-5 made an interesting decision driven by their research findings, right after they are assigned with designing cathouses and feeding area for a group of cats in the campus. Interviews showed that also stray dogs live in the same field that stresses the cats when they are feeding and resting. Thus, students have chosen to focus on a specific tree trunk, which provides a natural structure for locating a cathouse preventing dogs stressing them. Increasing the height is proposed as a solution by students. During phase 1, students measured the tree repeatedly, produced a bunch of mock-ups to test their designs until they finalize the drawings (Figure 8).

Figure 8. Team 5-Measuring the tree trunk (left) testing mock-ups (right)

In phase 2, students obtained sheets of chipboards by contracting sponsorship. They made most of the manufacturing by themselves (Figure 9) without needing and outsourced labour, highlighting that choice of material was considered right, as chipboard is easy to handle, as well as it is relatively cheaper than other woods and composites.

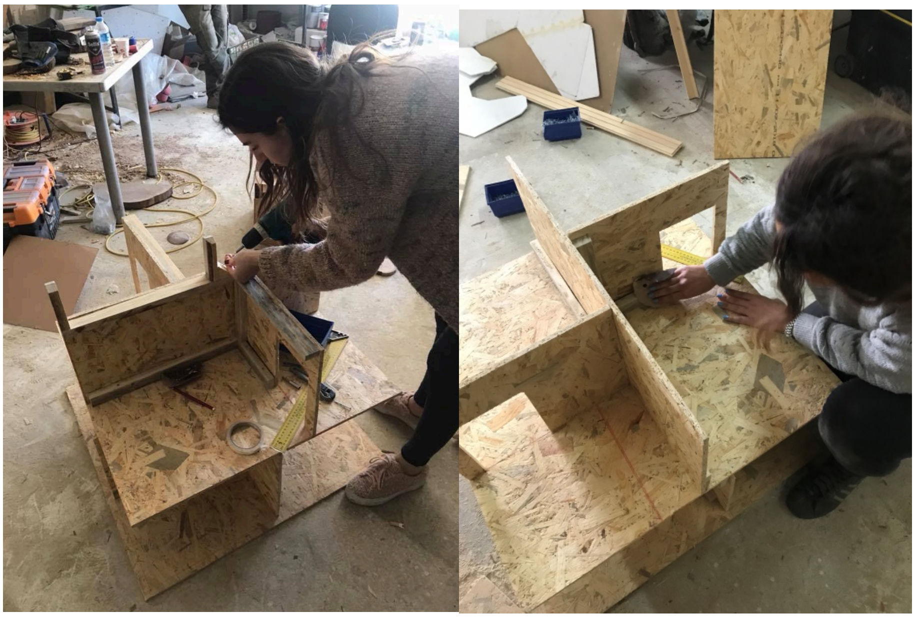

Figure 9. Team 5-Assembling the chipboard parts (left) polishing the surface (right)

Team-5 is exemplary for proving that designing with broader considerations lead to more successful processes. It took a while until cats begin to use the housing due to the smell of varnishing. However, Team-5 faced no other problems than waiting for the smell to dissolve. Final prototypes of Team-5 can be seen in Figure 10.

Figure 10. Team-5 House and feeding unit for group of stray cats

Team 7- Housing and Feeding Units for Multiple Cats

Members of Team-7 focused on increasing awareness by socially influencing campus life. As they are focused on a different campus than Team-5, their constraints are notably different too. These cats were already being cared well by volunteers and there was no factor such as stray dogs stressing them. Thus, students aimed to focus on raising awareness by designing a product with considering aesthetics and user experience, instead of satisfying only the basic needs of cats somehow. Their research showed that using marine plywood would prevent moisture based product life problems, with a minor increase in costs. However, plywood can only be laser cut when the manufacturing costs matter. Thus, in the first phase, students proposed a design which is manufactured by laser cut but no other post-processes and which can also be assembled without any tools, adhesives or else.

Laser cutting plywood is also advisable, as Team-7 could manage prototyping costs only by themselves, saving the time which they would spend for searching sponsorship and making them able to prototype more than once, to optimise better. By this means, students were able to solve the water-leaking problem from the roof joints that occurred when the sealing is tested (Figure 11).

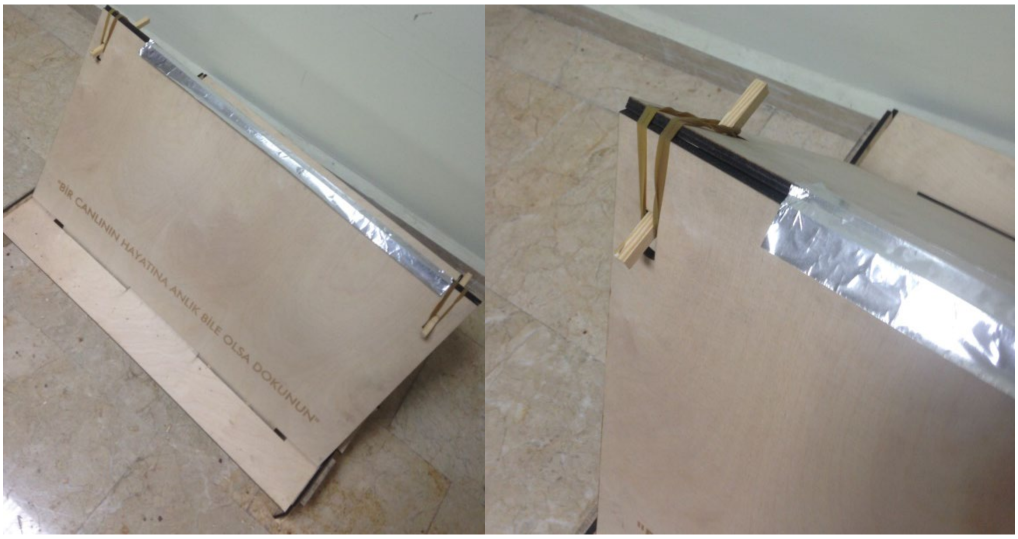

Figure 11. Team-7 Testing mock-up solutions for water leaking problem

The final phase was satisfying as the cats were willing to use the houses (Figure 13). Students demonstrated unpacking a flat package and assembling a cat-house in front of the jury. Going beyond the basic constraints during field research and deeply analysing the materials and production methods, helped students to produce houses with better finishing quality and considering further needs such as packaging or logistics. Even if they have faced a major design problem, students had enough time to figure out a proper roof coating solution, thanks to the decision of manufacturing method that lead them to manage the process more effectively.

Figure 12. Team-7 Houses and feeding units for group of stray cats

Team 8- Houses for Individual Dogs

Students of Team-8 were assigned to produce individual houses for a number of dogs. In phase 1, after they proposed a few different approaches, students focused on combining another social issue with taking care of stray dogs. They focused on recycling wooden euro-pallets to produce houses, which are very cheap to outsource. Even if their material decision had a disadvantage of being unable to use computer-numeric production and disassembling pallets by hand, recycling let them leave less carbon footprint behind. Thereby, Team-8 showed responsibility for both social issues at the same time. Different design approaches of the students are shown in Figure 13.

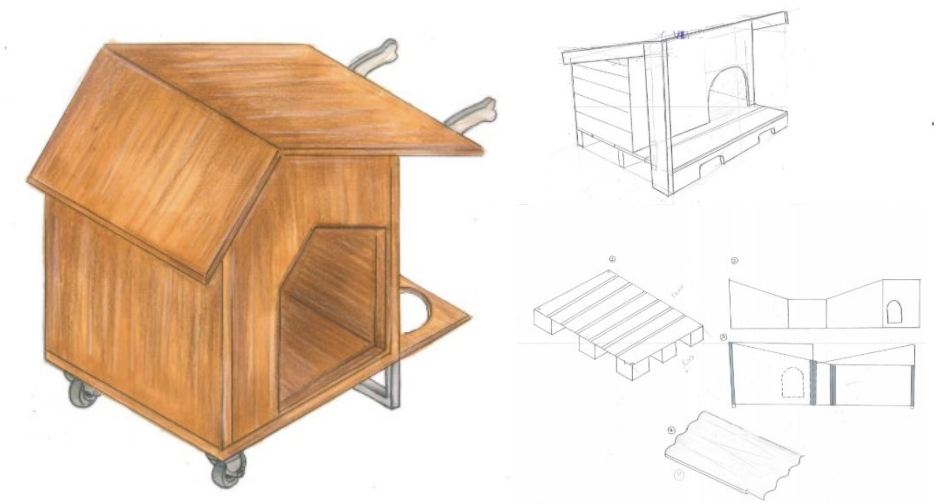

Figure 13. Team-8 Early (left) and matured (right) design approaches for dog houses

During phase 2 (prototyping), some of the wooden parts of pallets broke as the students were polishing the surface. However, as it is very easy to find scrap pallets for almost free and as they are lightweight, it took no time for students to obtain another pallet to continue production. Thus, using recycled material helped them to overcome the crisis. Students only outsourced the scrap pallets, which made them do a lot of hard work by themselves (Figure 14), yet improving their learning outcomes as observed.

Figure 14. Team-8 Assembling recycled pallet parts to form a doghouse

Even if the students were limited to obtain aesthetically satisfying results due to the pallet recycling decision, they afforded the costs without needing a sponsorship, took social design into a further level of sensitivity than expected and managed production with preventing a possible manufacturing crisis. Dogs were curious to meet the house produced as seen in Figure 15, which fulfils the most important constraint: Developing a serviceable social design for the stray animals.

Figure 15. Team 8 Housing Unit Design for Individual Dogs

Results of post-project student questionnaire

Criticism of the students is preferred to discuss the efficacy of the new teaching method, as such an evaluation provides more reliable findings than self-criticism. Students scored their learning outcomes affected by experiential learning by the production method in social design for stray animals. 33 of the 35 students who participated in the project completed the questionnaire. Results are shown below in 6 parts.

Part 1- Learning professional skills: In these first 11 questions, students rated the impact of new methodology on their professional skills (leadership, business communication, compatibility in teamwork, visual and verbal presentation, project management, analysing design process, analysing environmental conditions, identifying user needs, field researching, cognitive skills, understanding design thinking process). As shown in Figure 16, at least more than two-thirds of the students agreed all 11 statements. Increase in leadership skills is the least agreed outcome, yet only one-third of the 33 students rated the question by 3 out of 5, as the others were satisfied. Notably, all of the students agreed or strongly agreed that field research is critical in design, and more than 90% of them think they comprehended the importance of analysing these researches. In addition, more than 95% believe that they take environmental conditions critical in design processes as an outcome of the project. Results of “compatibility in teamwork”, “visual and verbal presentation”, “cognitive skills” and “understanding design thinking process” mark that the new method does not lack in other learning outcomes as at least three-fourths of the 33 students rated the statements 4 or 5 out of 5. Even if 85% of the participants agreed or strongly agreed that they can identify the user needs hereupon, remaining 15% were neutral, probably because of dogs and cats are harder to analyse such observations than humans are.

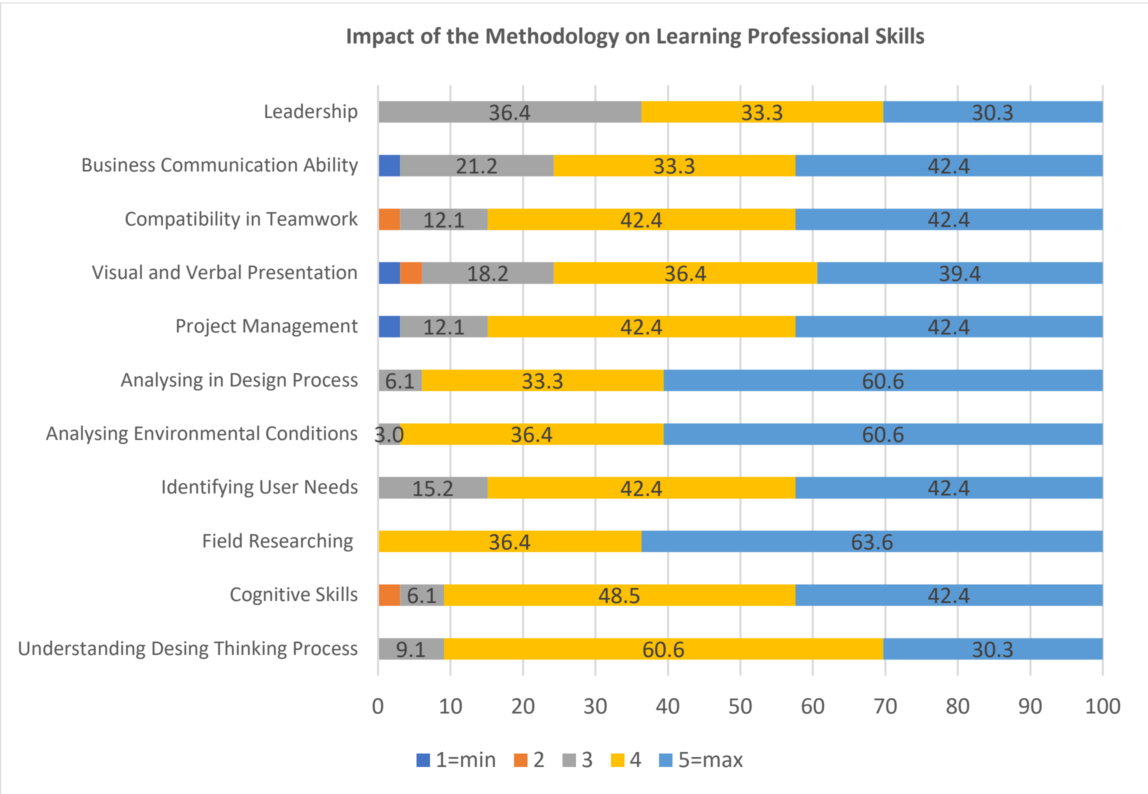

Figure 16. Analysis of post-project questionnaire part 1

Part 2- Learning technical skills: In the next 4 questions, students rated the impact of new methodology on their technical skills (understanding and applying the material, production techniques, anthropometrics, cost analysis). More than 90% of the participants agreed that they gained practical knowledge in materials and production technics expectedly, as they have faced and solved many material and manufacturing based problems. Even if a few students were neutral or unsatisfied about their improvement in anthropometrics knowledge, the majority of them agreed that they are now better in comprehending the ergonomics. Instead of other design projects, focused on consumer electronics, for example, social design for stray animals contains both human and animal factor. Thus, high satisfaction levels can be explained accordingly. Less than 10% were neutral or unsatisfied when evaluating the outcomes of the project on improving their financial skills. As it was probably their first time making cost analysis, most of the students agreed that they are better in financial management hereupon. Distributions of answers to these 4 questions in part 2 are shown in Figure 17.

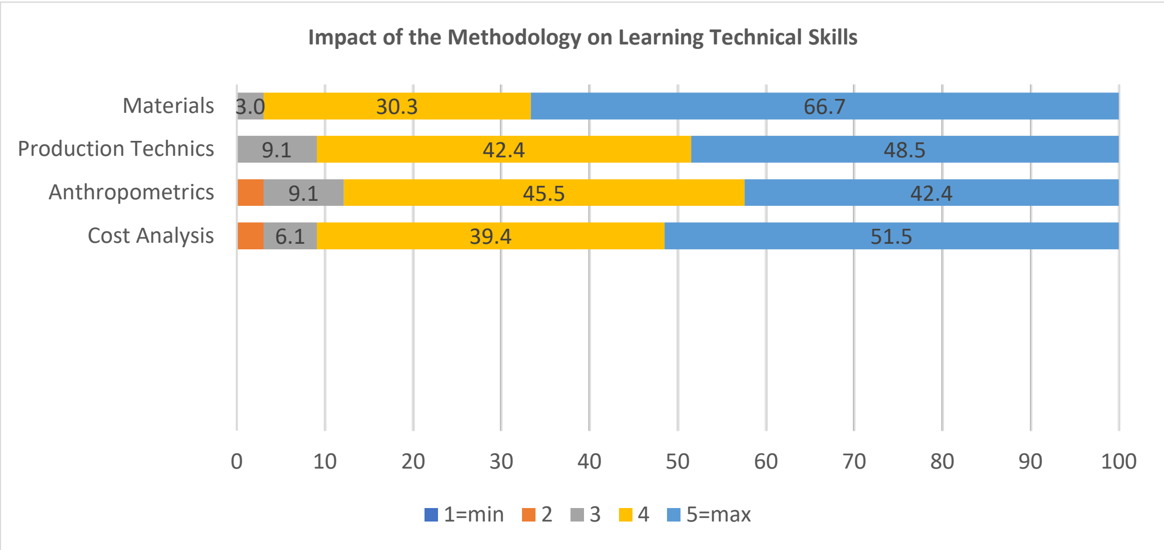

Figure* 17. *Analysis of post-project questionnaire part 2

Part 3- Impact of Field Research throughout Design Process: In the next 3 questions, students rated the impact of field research throughout the design process. All these 3 questions are left unanswered by 1 student. However, the reason for the non-response is unknown. Even if all of the students considered that field research is critical in design (see Figure 17), almost half of them were neutral or unsatisfied when answering the statement that the field research improved their motivation (Figure 18). Surprisingly, one-fifth of them rated that “field research made our design more successful” statement with less than or equal to 3 out of 5, yet 85% of them agreed that it prevented meeting unpredictable problems. As field research is quite challenging compared with *googling*, lack of students’ resources (convenient time or observation equipment), and physical fatigue can be discussed as the reason of decreasing motivation in near half of the students. Findings mark that field research promotes the learning outcomes, yet it may be better in motivating students if physical fatigue is less.

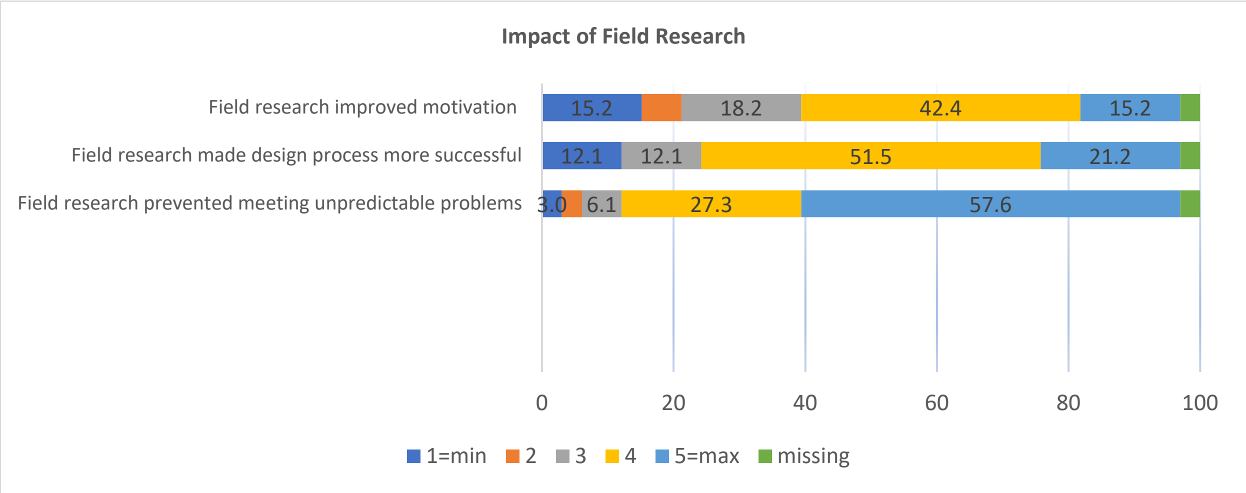

Figure 18. Analysis of post-project questionnaire part 3

Part 4- Comparison with traditional studio courses: In the next 3 questions, students compared social design for stray animals project with traditional studio courses. 2 questions are left unanswered by 1 and 1 question by 2 students by unknown reasons. It is obvious that full-scale production motivated students (94%) even it was notably challenging for them. All of the valid answers marked that participants agree or strongly agree that the new method improved their practical knowledge in production techniques and materials, more than traditional courses would. Also, almost 80% of the students considered that social design for stray animals project developed their vocational abilities. Distributions of answers to these 3 questions are displayed in Figure 19.

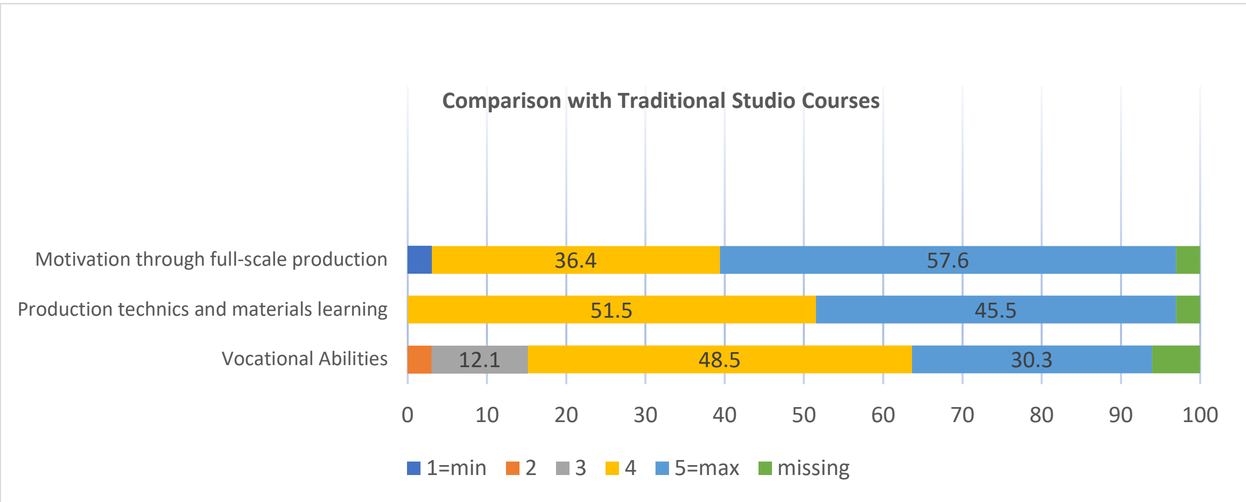

Figure 19. Analysis of post-project questionnaire part 4

Part 5- Impact of Social Design on Educational and Personal Development: In the next 8 questions, students rated the impact of social design on their development in both educational and personal level competencies. Participants scored the acceptability of the given sentences on a Likert scale of 1 to 5, similar to the previous sections of the questionnaire.

Q1-This project raised my awareness of animal rights.

Q2-This project made me comprehend that design is crucial for animals to live better.

Q3-This project showed me that industrial design has a social effect.

Q4-By producing our designs, we have made a sustainably positive social change.

Q5-Collaborating with third parties (communities, sponsors, university employees, students, people who care the stray animals, etc.) affected the project positively.

Q6-I believe I am more interested in social responsibility projects.

Q7-I think both my vocational and personal skills are developed.

Q8-I was more satisfied compared with traditional courses.

As seen in Figure 20, at least 70% of the students agreed or strongly agreed on all of the statements. Even the reasons for neutral and unsatisfied answers are unknown, it is discussed that some of the students could be considering that they are already socially responsible, desiring a broader influence on this specific social issue or contrarily not interested in the social design topics.

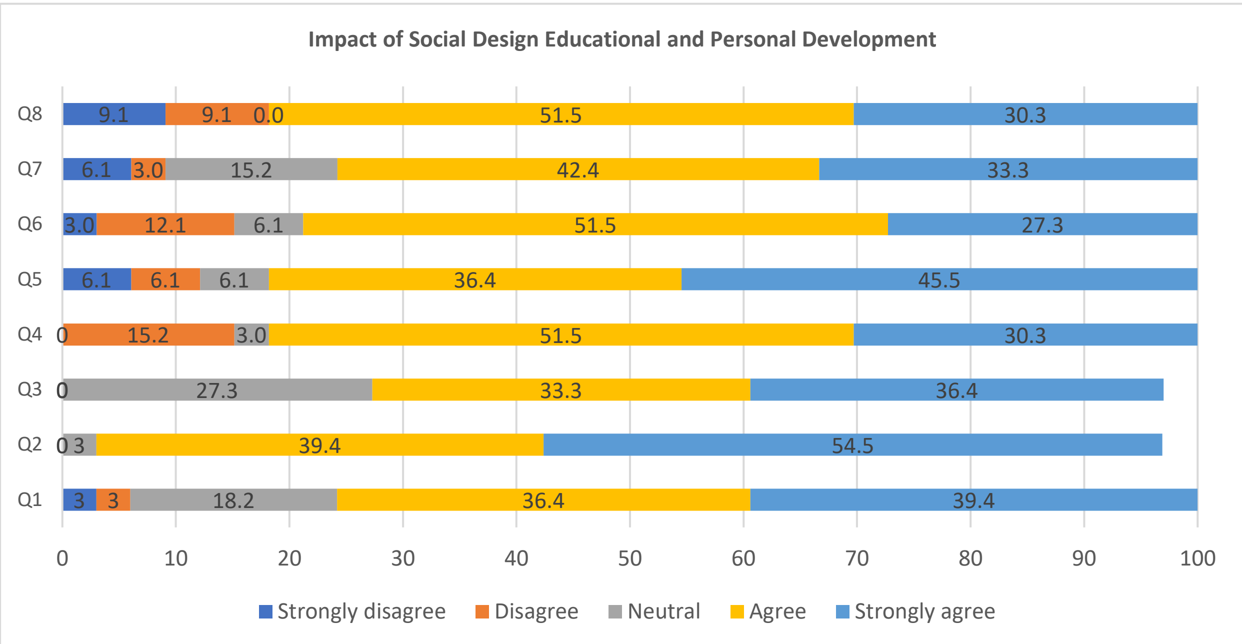

Figure 20. Analysis of post-project questionnaire part 5

Part 6- Criticism for a Hypothetical Participation in a Similar Studio Course: In the final 2 questions, students rated their willingness to participate in a similar course and hypothetically answered if they would succeed better or not. Each question has a non-response by 1 participant due to an unknown reason. Nearly one-third were neutral when evaluating their willingness, none of them were unsatisfied, and two-thirds did agree or strongly agree to participate again. Almost all of the students agreed that they would be more successful, marking that learning outcomes were notably effective (Figure 21).

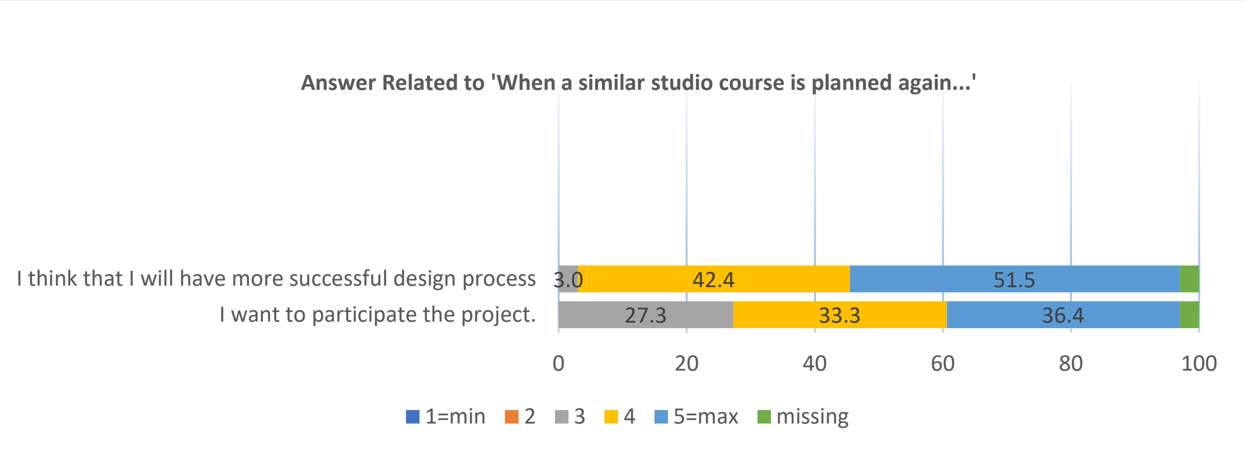

Figure 21. Analysis of post-project questionnaire part 6

Instructor assessments of the projects

Unlike the 5-point Likert scaled students' questionnaire, evaluations of instructors are based on scoring previously determined 9 fundamental outputs from unsatisfactory, marginal, good and outstanding. The meaning of each score for each question is briefly given in written form to the instructors. An essential part of these meanings can also be found below tendencies are explained in detail. As seen in Figure 22, mean scores given by instructors to all of the 7 projects show that improvement in these all 9 skills is gathered mostly in "Good". Instructors considered that production quality of prototypes improved at most and visual presentation skill at least. As even the highest unsatisfactory levels are less than one-third of the instructors, it can be discussed that they are generally satisfied quantitatively.

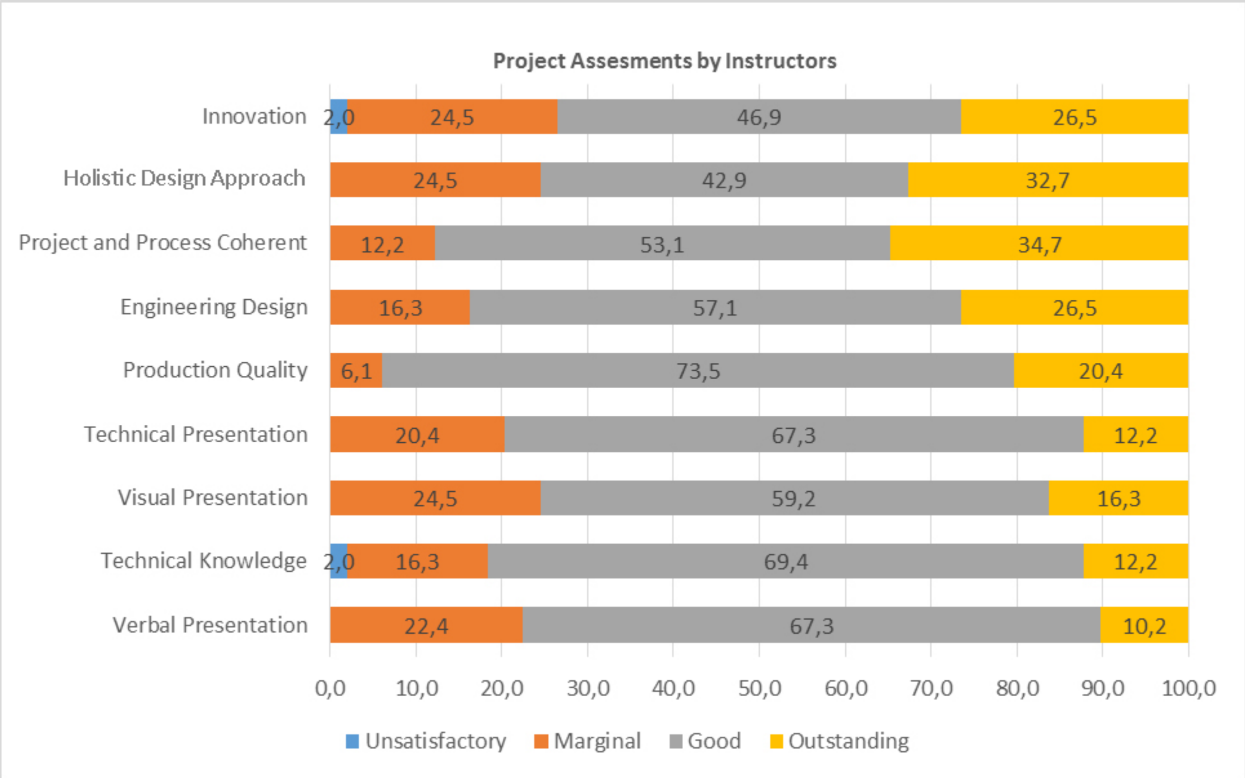

Figure 22. Analysis of project assessments by instructors

Additionally, 'Good' grading can be considered as a positive score since it is very difficult for the instructors in design schools to assess a project fully successfully.

According to Figure 22;

Production quality that is scored 73,5% ‘Good’ grade means that the prototype is acceptable. There are minor failures, such as surface finish, colour, prototype is in line with the project. Technical knowledge that is scored 69,4% ‘Good’ grade means that students have enough knowledge to answer questions asked by audiences as expected. The technical presentation that is scored 67,3% ‘Good’ grade means that the technical details of the presentation are sufficient for the understanding of the project. There are no major defects.

The verbal presentation that is scored 67,3% ‘Good’ grade means that students use verbal communication skills to express the project to audiences. The visual presentation that is scored 59,2% ‘Good’ grade means that the presentation is sufficient to describe the project, but there are 1 or 2 of basic design defects.

Engineering design that is scored 57,1% ‘Good’ grade means that students understand technical knowledge like ergonomics, production, mechanics, mechanism, form, material, and system. There is a meaningful and logical synthesis between design and production, but it is not so impressive. Coherency between project and process that is scored 53,1%

‘Good’ grade means that final design is generally coherent with findings and targets. There are inconsistencies that are not considered important; the final project can be improved.

Innovation that is scored 46,9% ‘Good’ grade means that it is an improved version of the existing product/system/services partly original, new and innovative. Holistic design approach that is scored 42,9% ‘Good’ grade means that the project focuses on product and other criteria as expected, but there is no impressive output.

According to observations of the instructors, for sophomores taking the ‘Product Design II’ course, all of the projects are generally acceptable and satisfactory. However, the scores of students in technical knowledge and presentation in particular are less than other scores. It can be discussed that succeeding *in a sort of way* is not what instructors expect. Instead, they are focused on educating the right way. Also, innovation scores are discussed as lower than expected.

Discussions and Conclusion

Since it was widely accepted that industrial designers could significantly influence the development and transformation of society, design schools and institutes have begun to deal with social design issues. However, generated social design models mainly focus human needs, the issues about animal welfare and interactions between stray animals and humans are generally disregarded.

This study proposes and presents a teaching toolkit for social design education combining design thinking and product development process and consisting of nine fundamental phases. The toolkit is designed based on the claim that social design could be learned just by the practised-based approach (Heller, 2018) and combined the design thinking approaches or pedagogy of three other toolkits (ArtCenter College of Design, 2018; FROG, 2018; IDEO, 2018). The teaching method is implemented into the ‘Product Design II’ course at Gazi University. The methodology of the project is designed to fulfil the determined learning outcomes. Students developed kennel and feeding station designs for stray animals and produced them. The applied toolkit is observed and questionnaires for students and instructors are preferred for evaluating the toolkit.

Findings indicated that in most phases of the project the outcomes are as expected. Designing for the real world instead of a hypothetical project, obliged students to research in the field voluntarily, comprehend the environmental conditions and determine the needs of participants in depth. However, even if nearly two-thirds of the students believed that the field research prevented design-based problems, a notable number of them evaluated in-depth research as motivation-breaking, probably resulting from the physical effort needed. Producing full-scale prototypes is inherently effective in teaching materials and manufacturing, anthropometrics and cost analysing compared to conventional studio courses. Findings validate the previous study (Yamaçlı, Özen & Tokman, 2005) which claims prototyping increases production-based learning. Most of the students also agreed or strongly agreed that producing their designs motivated them as well as improving production-based skills even it required a lot of hard work.

Being in collaboration with non-profit organizations, sponsor, manufacturers and suppliers was an opportunity for students to improve their business communication and project management skills. It is comprehended that nearly three-quarters of the students evaluated the project as better in improving verbal skills compared to previous design projects.

As mentioned previously, design students are active learners; they prefer teamwork and hands-on activities (Nussbaumer and Guerin, 2000; Carmel-Gilfilen, 2012; Demirkan, 2016). Thus, students tending to be satisfied overall can be described by their increased motivation when designing for a social issue and producing for the real world, according to their answers.

Students continued to investigate how often targeted dogs and cats use their final products and whether there is a problem related to animal-product interaction or environmental conditions. As mentioned in detail above in the findings, teams made iterative revisions after producing. It helped students to comprehend the importance of the iterative design process.

The results of post-questionnaire completed by instructors indicated that the projects of teams were satisfactory in terms of production quality, technical, and verbal and visual presentation. Instructors discussed that students should have scored higher in innovation criteria. Yet, it has to be discussed in further studies, how innovation or holistic design approach should be evaluated in social design projects, as usually budget restrictions oblige students (or designers) to avoid solutions requiring high costs.

In summary, students evaluated the toolkit as improving their material and manufacturing knowledge higher than conventional courses and strengthening their motivation except being obliged to do field research. According to their answers project also increased their interests in social responsibility projects. However, comparing the results of a conventional social-design project is necessary to claim that production-based education is better in increasing these responsibilities.

The study was limited to the participation of 35 students at one university. Therefore, further studies with larger samples or similar studies conducted at other universities can be useful for criticising the toolkit from a wider perspective. Overall results of the project proved that this toolkit for social design education combining design thinking and product development process could improve competencies and learning outcomes of ID students.

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Empathy Thresholds in Transport Design Students

Andree Woodcock, Jane Osmond, Michael Tovey, Coventry University, UK

Deana McDonagh, University of Illinois, USA

Abstract

Threshold concept models offer a useful way of understanding aspects of design education. A threshold concept represents a gateway, or portal, to a more developed understanding and level of capability (Meyer, Land & Davies, 2008). Passing through a threshold can be transformative, irreversible, integrative and troublesome. Key transformations for design have been identified, such as gaining sufficient confidence in design thinking to enable solution concepts to be generated which are crucial to achieving capability as a designer.

Empathy has been recognised as a key skill by practicing designers, but one which is seldom formally taught in classrooms. Drawing on the experience of five workshops held with transport and engineering design students which aimed to broaden their empathic understanding, the authors discuss the extent to which empathy may be considered as a threshold capability.

Key words

empathy, design thinking, design education, threshold concepts, learning interventions.

Introduction

Designer Responsibilities

Designers' responsibilities can be characterized as covering two main roles:

- To represent the market and user requirements in determining the ergonomics, appearance and brand identity of the product.
- To integrate the market, user and engineering requirements into a whole design solution.
  (Tovey, 1992)

The former implies an alignment with user needs which requires an empathic approach where empathy may be defined as the ability 'to think outside of themselves and think of others' (Osmond & Turner, 2008). The latter requires the ability to synthesize a design solution as an overall concept. Both of these can be regarded as threshold capabilities which student designers need to achieve.

Design thinking capability

The ability to solve problems through creating designs is a fundamental design capability involving the movement from an initial brief through a mix of activities at the end of which there is a credible new design proposition.

Designing is often described as inherently creative, and as a poorly understood cognitive process which is difficult to teach (Lawson & Dorst, 2009). It is unpredictable, and there are many ways of designing well and successfully, with much variation between projects. A distinct aspect of designing is that it features solution-led thinking (Lawson, 2005), making it fundamentally different from the processes of social or scientific analysis central to other disciplines. The solution led approach can be applied to ill defined, or wicked problems (Buchanan, 1992), in which designers may not have all the information needed to solve a problem. As such they have to learn to tolerate uncertainty, and have the confidence to develop draft solutions, which may redefine and reshape the problem-as-given (Cross, 2006).

Design involves developing parallel lines of thought (Lawson & Dorst, 2009); one concerns the shape of the problem, its clarification and framing; the other focusses on developing ideas about its solution. Experienced creative designers are able to sustain several parallel lines of thought, even if they are incompatible or apparently irreconcilable, for extended periods in a design project. The creative reframing of the situation allows for new views and understanding, in which the various lines of thought can be incorporated in a higher-level set of ideas. Thinking along parallel lines, maintaining a sense of ambiguity and uncertainty and not being concerned with a single answer too quickly seem to be essential design skills.

Conceptual design can be described as the art of seeing the design situation in multiple ways to facilitate (Lawson & Dorst, 2009) the existence of ambiguity and uncertainty. Experienced designers are used to performing this 'little dance around the problem', taking stabs at it from different sides mixing rational, analytical thinking with intuition and creativity. This fundamental 'schizophrenia' is a defining characteristic of design which may explain the peculiar way of working that is a common trait of practice throughout the design professions. A principal skill of the experienced designer is getting the balance of activity right. Confronted with a design problem which can be tackled in either a problem-focussed (analytical) or a solution-focused (creative) way is a difficult choice for a designer and the project can fail if the balance is wrong. Being too analytical can lead to an unnecessary limitation of the solution space, while being too creative and generative can launch a journey into nothingness.

The ability to blend thinking styles is a fundamental part of being a designer (Tovey, 2015). The experienced designer, will keep switching between analysis and creativity, between 'problem' and 'solution' without any effort. This process has been identified in a number of contexts, for example, by Dorst (2003) and Cross (2006), in Tovey's (1984) notion of dual process thinking involving an incubation period, in Wallace's (1992) leaping between problem bubbles, and sometimes having to start again, and Daly, Adams & Bodner (2012) proposal of a progression through a hierarchy of capabilities. However, for young student designers this can be an uncertain threshold/liminal space.

Threshold concepts and liminal spaces

Osmond (2015) used the threshold concept framework to gain further insight into teaching design. A threshold concept is defined as being:

> 'akin to a portal, opening up a new and previously inaccessible way of thinking about something. [It] represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress. As a consequence of comprehending a threshold concept there may thus be a transformed internal view of subject matter, subject landscape, or even world view.' (Meyer & Land 2003, p. 1)

Thus, a threshold concept represents a gateway, or portal, to a more developed understanding and level of capability (Meyer et al. 2008). A threshold is:

- transformational,
- irreversible (once learnt, impossible to forget),
- integrative (enables conceptual leaps within and outside the discipline field), and
- troublesome (uncomfortable, with resistance only accepted after some resistance).

Progressing through a threshold can be impeded by rigid ways of thinking including ritual, and inert (disconnected) knowledge, conceptually difficult knowledge (which relies on mimicry), alien (or counter intuitive knowledge) and tacit knowledge (Perkins, 1999). This can leave students struggling within a liminal space, where they flail, as they search for understanding. In new spaces, where technologies are being brought together, new user experiences are being designed, or new products created, the designer has to re-educate him/herself, breaking from traditional educational conditioning. The threshold concept can be seen as a process or moment in time when the designer acknowledges a shift in their understanding.

As a transformational process, passing through this liminal space (or gateway) can be uncomfortable for students who may be required to shed old forms of knowledge and 'ways of knowing and doing'. In educational practice, the gateway portal is viewed as having four stages:

1. Sub-liminal stage, which concerns student knowledge of the existing rules of engagement in the subject. Depending on their previous educational background and life experiences there will be variations of understanding on entry.
2. Pre-liminal stage associated with how confident students are as they approach the threshold concept portal.
3. The portal where there will be variations in how well they handle an unsafe space, and whether or not they can pass through it.
4. Post-liminal stage where students emerge with new capabilities.

For educators, such moments can be crucial, enabling curriculum design by pinpointing diagnostic points for tutors as the waypoints to be navigated, where the key transformations they wish to bring about take place (Meyer et al, 2008).

The tolerance of design uncertainty: how to uncover a threshold concept
Osmond & Tovey (2015) used the threshold concept framework to identify tolerance of design uncertainty as being crucial for design, where tolerance of design uncertainty is defined as:

> '…the moment when a student recognizes that the uncertainty present when approaching a design brief is an essential, but at the same time routine, part of the design process.' (Osmond & Tovey 2015)

This threshold concept emerged from a study undertaken to understand how Coventry University (UK) undergraduate design students negotiated their way through this threshold. Eighty-nine students took part, most of whom were interviewed twice a year from entry to graduation, over a 5-year period. The analysis showed that some students experienced a significant problem during their first year of study, characterised as a lack of confidence in making the creative leap to producing design concepts. This insecurity might be explained through their previous experience in educational systems that fostered a mind-set of 'tell us what do we need to do to pass'. Their undergraduate design course required them to employ new levels of creativity, which they found to be troublesome and anxiety-provoking. Held back by their previous experiences and unable to embrace new ways of working and trust in themselves or the educational process they remained stranded in a sub liminal space. Unfortunately, this proved to be too much for some students who subsequently left the course. For others, the process they went through instilled in them the confidence and techniques to deploy a combination of intuitive and analytical design thinking and thus produce solutions. Crucially they reached the point where they could debate and defend their designs with industrial design staff.

This ability to think holistically backed by analysis is a fundamental part of designing, which requires an approach to teaching design to provide an appropriate environment and a sympathetic curriculum to support designerly understanding.

Table 1. Toleration of uncertainty mapped against Meyer and Land's characteristics (Osmond & Tovey 2015)

Characteristic	Description as applied to toleration of uncertainty
Transformative	Students accept that the toleration of design uncertainty is the jumping off point to innovative design
Irreversible	This transformation incurs a cognitive shift in terms of students' design confidence
Integrative	Students recognise that everything they learn and experience is a legitimate source of inspiration (for example, accepting that surfacing around thinking about subjects that are not directly related to their task may turn out to be the most important part of the process).
Troublesome	Students accept that they will constantly experience and re-experience this 'surfacing around' as they hunt for a solution, even when they attain the status of professional designer.

During the initial study of threshold concepts, it was hypothesised that the development of empathy might be a threshold concept (Osmond & Mackie 2012). This was noted during an ergonomic module which emphasised a link between design and user needs (Osmond & Turner 2008). It was clear that students were experiencing difficulty in moving beyond the 'I methodology'.

Most undergraduate design students tend to be able-bodied 18-24-year olds with 'limited life experience' (Moody, Mackie & Davies, 2011). They begin by basing their design decision-making on their personal perspective (e.g. designing for themselves). They may continue to want to design exciting, innovative products for people like themselves. However professional designers are required to design for 'the other'. Limited opportunities exist within the curriculum to enable students to engage with or research about different populations. This lack of experience combined with a lack of empathy and a high toleration of uncertainty may lead to design which fail to address the needs of the 'other'.

Teaching empathy using Discrete Learning Interventions (DLIs)

In this research, Discrete Learning Interventions (DLIs) are used to enable students to pass through, or gain insight into, key thresholds required by their profession. If DLIs can be used to identify the difficulties students experience in attempting to gain capabilities in certain areas, they have potential as useful pedagogic and diagnostic tools when linked to formative evaluation and reflection. Key here is integrating the DLI and the wider curriculum, so that a DLI does not exist in isolation, but its value is extracted, and students/staff can see and recognize their expertise of design skills.

For the purposes of this paper a DLI is one which is delivered by expert tutors external to the course for a fixed amount of time. Any design exercise in which the students engage is bounded in time and may not necessarily feed directly into the curriculum. Participation in the DLI in this research was voluntary, and provided students with experiences which they would not normally be offered on their courses. Where the DLI was offered above and beyond normal teaching and learning activities, students were offered financial incentives to take part.

The research draws on five DLIs with different cohorts over 2 years. The main objective was to perfect the DLI and show its benefits in increasing the empathic capability of students. All activities were supported by a grant from the Frank Jackson Charitable Trust. Although the key concepts and methods remained, the implementation of the DLI varied between groups as a function of time, resource and student availability. Owing to these variations separate medium – high level ethical clearance was given for each instantiation of the DLI. Unless stated otherwise all activities took place at Coventry University (UK).

Table 2. Summary of cohorts

Ref	Discipline	Cohort details	DLI experience
DLI1	Transport design	5 undergrads (2017) undertaking final assessment	Students self-selected following a lecture on design for the elderly and empathy and were supported with tutorials, classroom based and real-world experiential simulations during the concept design phase of their project involving design of transport for older users. This ran over 2 terms
DLI2	Engineering design	30 undergraduate engineers enrolled on a humanitarian engineering module (2017),	2-hour low fidelity classroom based experiential simulation workshop to encourage them to develop a more empathic understanding of older transport users
DLI3	Transport engineers	20 Serbian undergraduate engineers attending the 6th Humane Cities Conference (2017)	2-hour low fidelity classroom based experiential simulation workshop to encourage them to develop a more empathic understanding of older transport users
DLI4	Transport planners /professionals	10 delegates enrolled for an interactive workshop at the IPATH conference in US (2018)	90-minute low fidelity classroom at the IPATH conference in US (2018) based experiential simulation workshop to encourage them to develop a more empathic understanding of older transport users
DLI5	Transport design	5 MA transport design students participating in challenge to design products to support companionship	This involved low and high-fidelity simulation in and out of the classroom, group tasks and design critique over a 3-day period.

The approach used was to evoke the designer's own experiences in a domain relevant to the user, with designers trying to simulate the user's condition through ideation. Any type of representation designed to understand, explore or communicate what it might be like to engage with the product, space or system may be described as 'experience prototyping' (Buchenau & Fulton Suri, 2000). Students engaged in short individual and group activities related to mobility and travel - in a classroom setting (e.g. route finding, using a phone, eating and drinking, playing games (cards and word search) and removing outer garments) and out of the classroom (DLI1 and 5) where they used different forms of transport while having restricted mobility and sensation. In relation to this, a technique which is gaining attention is the use of whole-body simulation suits in design and transport research to provide designers with an immersive empathic experience [e.g. Schmidt & Kekel 2013; Armstrong, Stone, Immel & Hunter-Zaworski, 2015). An ageing SUIT was used with DLI5.

The DLIs were designed to take the students through staged of discovery, immersion, connection and detachment (Kouprie & Visser, 2009*)*.

Discovery

In this stage participants were provided with small classroom immersive experiences to raise their curiosity and to start to expand their empathic horizons. Materials provided included

- Glasses: simulating a variety of conditions, such as macular degeneration and cataracts
- Ear plugs: to reduce hearing in one or both ears
- Masking tape used totape thumb and forefinger together on dominant hand, and bind three fingers together on non-dominant hand
- Thin gloves to reduce sensation in hands
- Bandages to restrict movement

Immersion

Typically at this stage the designer moves out of his/her office and explores the user's world. DLI1 and DLI5 were able to do this using simulated suits. DLI1 students took part in a 'walkabout' where they were required to perform all activities involved in travelling from the university to the main rail station, boarding a train to a local station and returning. To support this 'experience prototyping', low fidelity simulations were used, including a range of visual impairment glasses (to simulate glaucoma, macular degeneration and cataracts), mobility impairments (crutches, wheelchair, tape to stiffen legs) and hearing loss.

We evolved a number of strategies to help students make the leap from personal experience to relating this to real people. For example:

- DLIs 1 and 3 were given semi-structured interviews and prompts to help them capture mobility experiences of older people. This was shared with others through a video repository and posters
- DLI4 consisted of transport planners and academics who were attending a transport conference in a particularly inaccessible location (Mackinac Island). They were asked to draw on this experience and relate how they had felt during the simulated exercises to the problems elders might have experienced if they undertook a similar journey.
- DLI5 participants were asked to create mind maps of grandparents on Day 1 and revisit these/consider their grandparents as end users of their designs. This was reinforced by asking them to draw their grandparents once they had produced initial concepts, to refocus them on the end users. On the last day they were asked to produce moodboards which captured how they felt when wearing the simulation suit. Moodboards provide designer with opportunities to express their understanding of the design problem utilising images rather than being restricted by words.

Connection

This requires students combining the information they had been provided on empathy and ageing, their own experiences and relating this to real world situations and people. This process was supported in the debrief sessions where students were given ‘quick note’ sheets to record their thoughts before, during and after the experience. They shared these with the rest of the class. Although they have a felt experience, they still may not be able to transfer this feeling into design activities.

Detachment

This involves the student or participant stepping back into the role of designer, to deploy the new insights into the current design task. Our participants were a convenience sample, all except the engineers in DLI3 had elected to attend our DLIs and were aware that we were trying to improve transport for older people, by increasing their empathy towards elders in whatever capacity they encountered them. As it was not possible to include a design activity in all groups, at the end of the session, participants were asked to step back and think how they would employ what they had learnt e.g., through brainstorming in groups (DLIs 2-4) or creating individual pieces of work DLI5, or showing how their broader empathic horizons effected their designs.

Results

The overall aim of the research has been to develop a DLI which could increase the participants’ empathy towards older transport users as reading statistics on ageing populations and user requirements does not necessarily mean that students understand the felt experience. We would argue that simulations can have profound and unexpected effects in how one feels, and that this can also be transformative if it is acknowledged and brought into play.

If designers, engineers and transport planners apply empathic thinking to urban and transport planning, design of vehicles and transport infrastructure then it is hypothesized that more age friendly transport will start to emerge.

Participant feedback suggested that there had been a change in some in level of empathy and they backed this up by suggesting how they would apply this new understanding in their work and everyday experiences. For example, the Serbian engineering students in DLI3 had never experienced such a method and were keen to use it in their classes. They felt that they focussed too much on the mathematics of construction and forgot about the people who would use their designs. They wanted to champion the users in their activities. Their feedback included ‘the workshop is a great practice for all people to accept disabled person and much more to understand these people. Our responsibility is to help them to have as much normal world (normal means accessible, like for non-disabled people, Thank you for this opportunity.’

DLI3 students reflected on how they would be more thoughtful and tolerant of older people using public transport. This transference out of the classroom was also noticeable in one of the participant’s comments in DLI1 who started to interpret things in a new way, for example he commented that he found himself watching an old lady struggling down some steps in Coventry, and for the first time understood why she was moving so slowly – because it was painful for her. This could be directly attributed to the binding up of limbs to restrict mobility and walking with stones in the shoes to simulate diabetic nerve pain.

Engineering students in DLI2 considered how they might change their everyday behaviour by being more patient and helpful, show more understanding towards people in traffic, and by educating others about the effects of disability.

A student from DLI1 experienced unknown levels of anxiety when walking in a busy street with vision restricting goggles. He relied on reading people's faces to judge their moods and feelings. With restricted vision he could not do this and became fearful of the mood of a crowded high street. All students felt very vulnerable – which they had not expected – and were glad to remover their encumbrances

DLI2 was the shortest intervention. After each group activity they were asked to reflect on their experience of group tasks e.g. socialising, wayfinding and doing a shared task. Of key significance was how quickly they became isolated from the group (because they could not see or hear the activities) were left behind (or ignored) and simply gave up trying because it was too difficult.

This was also reflected in the comments of a participant DLI1 who embraced the method, experimenting with low level simulations at home. He saw the benefits of the method, asserted that he would use it as part of his future practice, concluding that the mobility, hearing and visual restrictions made getting shopping into and out of the car

> "… a mountain of a task, it made multitasking very difficult and delayed every task"

From an analysis of individual quick notes and group discussions most of the engineering students in DLI2 and DLI3 expressed deeper empathy for older people and those with age related disabilities and started to realise how difficult everyday life was for them. In terms of changes to their practice, they agreed for the need to champion and consult with differently abled users, and not design transport systems for the fittest. They could point to design features that they could improve e.g. lighting, size of fonts, acoustic signals.

DLI4 was conducted with transport professionals and academics from fields related to transport and health. They were somewhat sceptical of the approach, buy-in was difficult in this non student groups, and providing an immersive experience for them in 30 minutes was challenging. However, once they sensory and mobility restrictions they saw the potential of this approach. Their reflections and transference back into real life included ideas for discrete support for everyone at airports, where support staff are trained to look for people who might be having a problem, not necessarily just the elderly. Also, they wanted quiet space for themselves as carers with dependents and support so that they could take time out from being a carer e.g. to leave someone with a trusted member of staff while they went to the toilet, bought food or took time out during the journey.

The concept idea developed by one of the students in DLI5 revealed a more empathic understanding of the needs of elders and a more thoughtful approach. These are shown in figures 1 and 2 below. The first image shows a design for a walking stick handle, which is based on a handshake – representing trust, companionship, and human feeling. Although the design remained unresolved, it showed a more empathy and sensitivity to users than the initial functional designs.

The second concept was for shoes which opened up, like a clam, so they were easier to put on and take off. This could be traced to the difficulties the students experienced in the low fidelity simulation when they experienced difficulty removing their own shoes and putting on someone else's. This task was designed specifically to show the problems elders have with putting on shoes, and the problems' older partners may have in helping their loved one, when they might also have a disability.

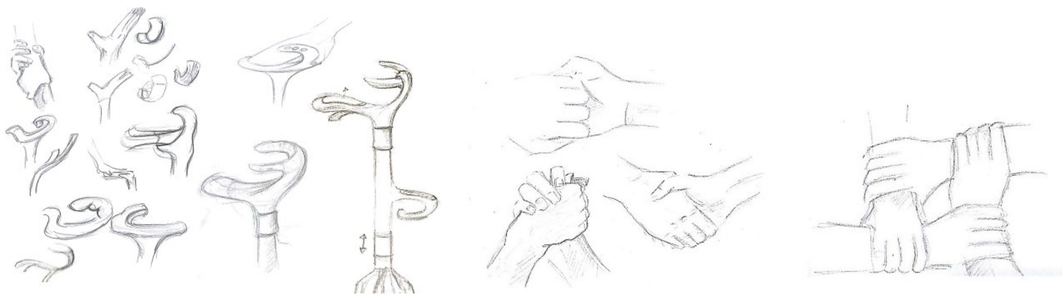

Figure 1. Movement in design direction following empathic modelling

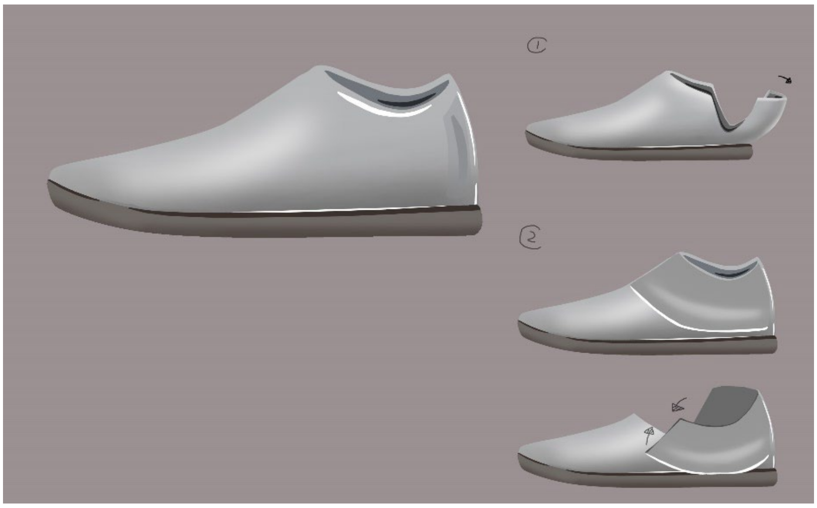

Figure 2. Initial designs for the 'opening shoe'

The evidence for empathy as a threshold concept

The research which established that the toleration of design uncertainty is a threshold concept did so through providing convincing evidence of its operation and efficacy. This was achieved through both identifying the nature of design uncertainty as a block for students and then developing pedagogic strategies which enabled the block to be overcome. The work was mapped onto the stages of the threshold concept theory as transformational, irreversible (once learnt, impossible to forget), integrative (enables conceptual leaps within and outside the discipline field), and troublesome (uncomfortable, with resistance to acceptance).

In the studies reported here we argue that achieving an empathic understanding of users as a crucial element in understanding user needs. Designers will not produce products which are properly attuned to their users, if they lack it. The empathic horizon (Woodcock, McDonagh & Osmond, 2018) is real and travelling over it is an essential journey for designers. We can thus map this against threshold concept characteristics as shown below.

Table 3. Empathy Horizon mapped against Meyer and Land's characteristics

Characteristic	**Designing for others is fundamental to design**
Transformative	Design students accept that the empathic understanding is essential to understanding user needs.
Irreversible	This transformation incurs a cognitive shift in terms of students' design approach.
Integrative	Students recognise that an empathic approach should give direction to their solution concepts and frame their evaluation of proposals, thus providing the overall shape for their design process.
Troublesome	Students accept that they will constantly experience and re-experience this empathic struggle to understand and connect with users, even when they attain the status of professional designer.

Thus, we can argue that empathic understanding is a threshold capability for design students. It is a very similar capability portal to the Toleration of Design Uncertainty with which it overlaps, but is separate from. However, although we have mapped empathy against Meyer and Lands' characteristics, we cannot speak to the longevity of the experience delivered through this pedagogic model: to this end the development of a future pedagogic framework should align with the four stages identified earlier:

1. Sub-liminal stage, which concerns student knowledge of the existing rules of engagement in the subject. Depending on their previous educational background and life experiences there will be variations of understanding on entry.
2. Pre-liminal stage associated with how confident students are as they approach the threshold concept portal.
3. The portal where there will be variations in how well they handle an unsafe space, and whether or not they can pass through it.
4. Post-liminal stage where students emerge with new capabilities.

Conclusions

In this article we have summarised previous work which established the relevance of the Threshold Concept model to design education. In that work, the key role of the designer as the creator of the draft solution which synthesised requirements was highlighted. This is normally achieved through proposing a design concept. Students who found they struggled to do this were at a considerable disadvantage. This has been labelled the toleration of design uncertainty and surmounting it is both essential and transformational. It thus conforms to the Threshold Concepts model.

We have also sought to summarise thinking on the importance of empathy as a component in understanding user needs and wants from designs. The empathy horizon represents the threshold of understanding the end-users which designers should aspire to achieve. Representing users in the design process is a key role for designers.

The studies we report on have clearly shown just how difficult design students found this to be. When confronted with the need to understand and put themselves in the position of users who are radically different from themselves, such as those with sight-impairment or mobility restrictions, they were shocked by how unfamiliar and difficult this is. This is of course good for their souls. But it is also a challenge for design educators.

We believe that we have shown clearly that achieving empathy represents a threshold of understanding which is essential in designing for others. In the work we have reported here we show that it conforms to the Threshold Concepts model and that it is similar to the Threshold of Design Uncertainty. The Empathic Understanding forms part of the pre-liminal space, which students approach as a portal of uncertainty. In order to develop the confidence and capability to pass through this portal they need to develop genuine and effective empathic skills. We are claiming that we have established the relevance of the model in this area, and that this Empathic Understanding represents a threshold capability. What needs further work is the development of a pedagogic framework that incorporates Meyer and Lands' four liminal stages (sub/pre/portal/post) as a baseline in order to bring design students to a level of confident capability in handling empathic design.

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The tacit design process in architectural design education

Elise van Dooren, TU Delft, Netherlands

Machiel van Dorst, TU Delft, Netherlands

Thijs Asselbergs, TU Delft, Netherlands

Jeroen van Merrienboer, Maastricht University, Netherlands

Els Boshuizen, Netherlands, Open University, Netherlands & University of Turku, Finland

Abstract

The purpose of the architectural design studio is that students learn to think and act like designers. However, communication between teachers and students seems to be problematic. Teachers barely seem to explain how designers work, which may be confusing for students. To learn professional reasoning processes and strategies, different teaching activities are involved, such as modelling, coaching, scaffolding, reflection, exploration and articulation. In the design studio it seems tradition that teachers only ask questions, while not articulating the design process.

This paper focuses on the research question of whether teachers in architectural design education articulate the main 'designerly' actions and skills, performed by expert designers, and if so, to what extent and in which manner? To answer these questions video-recordings of 13 tutorial sessions are analysed with the help of an educational framework of five generic elements. The framework consists of the basic design process actions and skills, and is specifically developed as a vocabulary for making the design process explicit and to train students in the design process elements. The main conclusion is that teachers refer to the design product in an implicit way. They leave it to the students to discover the structure and components of the design process more or less by themselves.

Keywords

design process, generic elements, design education, design skills.

Introduction

"One of the things that really bugs me about architectural education is that a lot of things are really implicit, remain under the surface and are not talked about." This statement, made by a student, is quoted by Donald Schön (1987, p. 98) in his case-study of education in the design studio. Schön observes what happens in the studio and concludes, among other things, that communication in the tutorial dialogue between teachers and students is problematic. For example, when Quist, the teacher in his case-study, tells the student she must ‘draw and draw’, he means that she must draw in the sense of experimenting, to discover consequences of different options. For students this might be unclear as for them drawing may refer to making a visual presentation only. Oxman (2001) refers to these phenomena in the design studio as “a neglect of attention to thinking in design as legitimate pedagogical content”.

However, the purpose of the architectural design studio is that students learn to think and act like a designer. They must acquire habits and patterns which are mostly used by experts implicitly. They have to learn ‘reasoning processes of professionals’ (Van Merriënboer and Kirschner, 2018). Collins, Brown, and Holum (1991) coined the term cognitive apprenticeship in education to emphasise the (mostly underexposed) reasoning and strategies experts employ. To learn these processes of thinking adequately, different activities are involved. They distinguish modelling, coaching, scaffolding, articulation, reflection, and exploration as teaching activities.

In this case study, the focus is particularly on articulation. Making the process of thinking explicit in the form of explaining and instructing, can help students in understanding ways to approach the design process and achieve adequate conceptualisations of the design process. For example, instead of the notion that designing is coming up with one single solution, students are confronted with the idea that designing is experimenting with different possible solutions and reflecting on them.

Our hypothesis is that teachers talk about the design process itself to only a limited extent, being traditionally not used to articulate the design process and not having an adequate vocabulary to do so. Therefore, a framework is developed based on a valuable body of design process knowledge (Van Dooren, Asselbergs. Boshuizen, Van Merriënboer & Van Dorst 2014). The outcome of this research is ‘summarised’ into five generic elements that design processes have in common. The framework has already been tested by interviewing designers with different design approaches (Van Dooren Boshuizen, Van Merriënboer, Asselbergs, & Van Dorst, 2018) and turned out to be a generic framework of the main common basic actions and skills. This framework is now used to investigate whether and to what extent teachers articulate the design process during design tutorials.

In the remainder of this introductory section, some thoughts behind the way students learn to design in the studio will be described. Then, briefly, the framework is introduced. The section ends with the main research question and sub-questions. The second section gives information about the research method. In a case-study, the current situation in a first-year design studio is video-recorded and analysed with the help of the framework. Then, the third section presents the results for each of the five elements, whether and to which extent they are addressed in the tutoring session. In the final and fourth section conclusions are drawn and the ways teachers may make the design process more explicit are discussed.

Design process and design education

Sense and myths

Why is the thinking process barely articulated in the architectural design studio? We see three at least possible explanations: (a) complex skills and actions cannot be made (completely) explicit, (b) teachers have (mis)conceptions about (design) education, and (c) it is just common use in the design studio tradition.

Firstly, regarding the possibility of making a professional set of actions and skills explicit, there is a discussion with notions such as tacit (Polanyi, 2009), implicit (Reber, 1989), knowing-in-action and reflection-in-action (Schön, 1985, 1987) at the core of it. On the one hand there is (tacit) knowledge, which people seem to be principally unable to make explicit. On the other hand, there is the conviction in at least the 'positivist' part of the world of science that all phenomena can be made explicit in an objective manner. In our work, we take the position that knowledge can be made explicit at least to a certain extent. It may vary in time and culture, but the aim should always be to derive a vocabulary as adequate as possible for describing the phenomena we experience. As Dewey argues: knowing makes us understand the relation between our actions and their consequences. A better understanding of these relations helps to focus better and act more thoughtfully, more intelligently (Logister, 2005).

Secondly, regarding the misconceptions about design education, listening to colleague teachers over the years, the first author has heard different explanatory thoughts, which seem to underlie the way teachers act in the design studio. Teachers seem to have formed a cognitive model of inconsistent pieces of information (Vosniadou & Brewer, 1992, Vosniadou,1994). Summarised in a statement of a teacher: 'teachers ask questions; they do not give answers'. Teachers know that academics and designers must be independent and critical. They must act scientifically and creatively, not taking for granted what others say, not 'following the rules'. As to learning a complex skill, teachers seem to be convinced that learning is (only) adequate if students make discoveries for themselves. On their own these thoughts are honourable theorems. However, taken into the extreme and in combination with each other, they even may be called a design education myth: you do not instruct, tell, explain or guide students. Nevertheless, making the reasoning processes explicit helps students in performing 'designerly'[1] actions and skills and in achieving and discovering desired professional qualities such as independency, critical thinking, and creativity. There seems to be no body of educational research supporting the idea of using minimal guidance. On the contrary, research points out strong instructional guidance in the case of novice and intermediate learners, for advanced students it may be equally effective. There is even research that suggests that minimal guidance may lead to misconceptions (Kirschner,

[1] Cross, N.G. (2007). Designerly ways of knowing. Basel, Boston, Berlin: Birkhauser.

Sweller, and Clark, 2006). It seems that teachers have forgotten what it is like to be a novice designer, that they have forgotten the confusion caused by not knowing 'what and how to do'.

Thirdly, teachers may simply not know how to talk about the design process. Being experienced, expert designers, most of the time they act implicitly. Not having a professional background in education, they seem to act as they remember from their own teachers in design education and they appear to talk with students as if they would with colleagues in their offices, discussing all kinds of product-related aspects. Therefore, we assume that a vocabulary for having a rich tutorial dialogue about the design process is needed.

A vocabulary for design education

Design problems are by nature ill-defined. Confronted with an open, unique and vague situation at hand, designers approach this in their personal way. However, they also have basic actions and skills in common. For the last decades, researchers coined adequate terms and notions to describe aspects of the design process, such as: reflection-in-action, conducting experiments, a web of moves, imposition of an order, and naming and framing (Schön, 1983, 1985, 1987), primary generator (Darke, 1979), a co-evolution of solution and problem spaces (Dorst and Cross, 2001, Lawson, 1994, 2006, Lawson and Dorst, 2009), and ideation and evaluation (Goldschmidt, 2014). Nevertheless, how valuable this body of knowledge may be, it is not easy to use in design tutorials, especially in the case of novices. Therefore, to make this personal, creative, open-ended and complex process of (architectural) designing more explicit, a framework, consisting of five interwoven elements has been developed (Van Dooren et al., 2014):

Designing is a process of experimenting, of trial and reflection, of exploring and decision-making. Designers play around and find their way in a series of experiments. They come up with ideas and means to express these ideas and test them in a process of reflection. In Figure 1 this is expressed with an erratic line with circles to symbolise the experiments.

This process of experimenting is given direction by a guiding theme or qualities. It acts as a hold during the process and helps in creating in the end a coherent and significant result. In Figure 1 the guiding theme is symbolised by two lines coming together; experimenting with(in) theme or qualities, whilst becoming more and more defined.

The process of experimenting takes place in different domains. For architecture: (a) form and space, (b) material, structure and climate, (c) physical context, site, (d) function, and (e) a broader socio-cultural, economical, historical and philosophical context. Designers have to consider all kinds of criteria and make statements concerning all these domains. Therefore, in Figure 1 the erratic line crosses all domains and relates these domains to each other through the act of experimenting: often a decision in one domain can be taken only in relation to the outcomes of experiments in other domains and has new implications for other domains.

The design process is inseparably embedded within a broader context: a personal and culturally defined frame of reference. Designers use and test patterns and images in a design project at hand, and they transform them into new patterns. In Figure 1 the frame of reference is symbolised literally with a frame, the blocks representing projects, patterns and other knowledge designers are aware of.

The process of experimenting is not possible without the help of a physical language of images and words: a laboratory or a (visual) language. In this laboratory the testing takes place, expected and unexpected implications of experiments can be discovered, all domains can be considered. Being directly related to the process of experimenting, in Figure 1 the laboratory of sketching and modelling is also symbolised by the circles of the erratic curve.

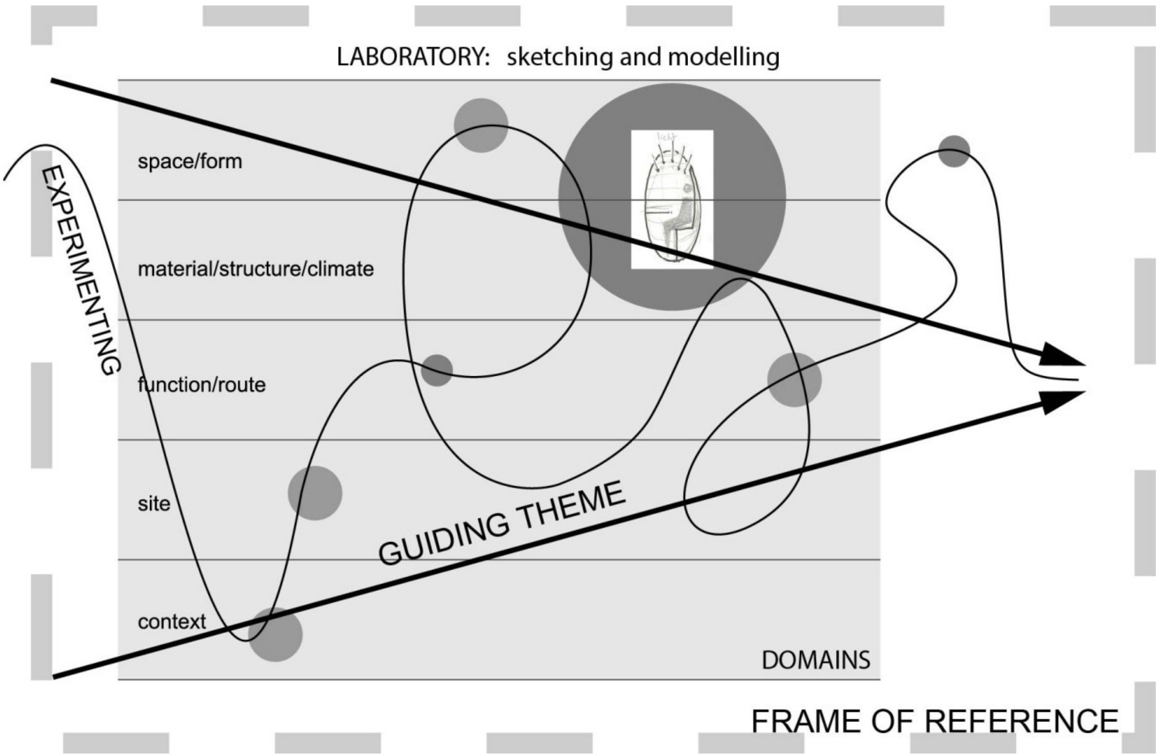

Figure 1. The five generic elements in the design process: (1) experimenting, (2) guiding theme, (3) domains, (4) frame of reference, and (5) laboratory (van Dooren et al., 2014).

The five elements are certainly not meant as a unidirectional design method. They do not form a prescription or recipe to design; they are merely meant to give insight into the 'designerly' reasoning processes and behaviours. The framework can be used in design education in different ways. The two key aims are (a) explanation of the design process in tutoring sessions in all kinds of concrete design situations at hand, and (b) organisation of design education: it may help in deriving practices to train essential design skills and actions. These main aims include all kinds of sub goals, such as working as an individual designer or in a team, and studying differences and similarities in the personal design approaches and methods of all kinds of different designers.

Because the framework is a vocabulary to articulate the 'designerly' actions and skills' performed by expert designers, in the case study presented here, it is used to analyse whether teachers in architectural design education articulate these actions and skills, and if so, to what extent and in which manner. Separately formulated in three sub-questions: (1) Do teachers articulate the generic elements when they discuss design products with their students? (2) If so: to what extent do they articulate the elements of the design process? (3) What kind of expressions do they use?

A remark before giving more information about the research method, the research in this paper focuses on architectural design, including urban and landscape design, but for reasons of readability, regularly the shorter notions 'designing' and 'design process' are used. At the same time, being basic and elementary elements, the framework may also be useful in other design disciplines as well (Van Dooren et al., 2014).

Research method

Participants

All thirteen participants (nine male and four female) are teachers in the first bachelor design project at the Faculty of Architecture TU Delft, the Netherlands. They are practising expert designers and differ in educational experience, ranging from only a few design projects to more than a decade. The teachers are observed and video-recorded at work in the studio, each time tutoring one student.

Setting

Each year twenty or more groups of nine novice students conduct the first design project of their studies. In the studio, students work individually on a given design project. They regularly have tutoring sessions in which the project at hand is discussed with their teacher in a tutorial dialogue. The BSc design assignment consists of designing a small house in a landscape (forest, dunes, ...). varying from a studio and house for an artist with the focus on the environment, a small neighbourhood with a public sculpture route, to a holiday home for two family members with the focus on different users (e.g. two brothers) and anchoring in a particular landscape. Out of a larger set of recordings, thirteen tutorial dialogues of different teachers and students were chosen at random; only the sound quality of the recordings affected the choice.

Procedure and analysis

The (Dutch) tutorial dialogues were recorded in the studio during three academic years in the period 2012-2015. The transcriptions were analysed and coded with the help of the program ATLAS TI. Two categories of coding were used. The first category consists of notions referring to the different actions and skills of the design process: the generic elements including synonyms and aspects of the elements (see Table 1). The second category refers to the extent in which teachers are implicit or explicit about the design process (see Table 2). This category was defined beforehand and refined during the first round of coding.

The coding of each transcript was completed in two equal rounds of analysing: first, by the main researcher (first author) and a student-assistant, in the second round by a colleague teacher and another student-assistant. Only five cases (presented in the result section) were topic of discussion: the decision was taken by the main researcher (first author).

Also, extra information was collected, such as the duration and structure of a tutorial dialogue. To get insight into the structure (start, middle and end), text fragments were distinguished based on content. Each fragment consists of one or more items, being the smallest part of the text, textually belonging together, often about one aspect of the design product at hand. Fragments and items helped in deciding which notions belonged to one code. When a notion, such as 'you have to vary' was mentioned two times in connection with one item, it was coded as one.

Table 1. Notions referring to actions and skills of the design process.

generic element	notions referring to (parts of) the element
experiment	search / explore / alternatives / investigate / variants / analysing / association / decision taking / testing / reflection / looking for implications / ...
guiding theme	concept / idea / quality / focus / primary generator / design question / essence / starting points / …
domains	aspects fitting together / strengthening each other /...
frame of reference	references / examples / patterns / principles / rules of thumb / abstraction / …
laboratory	sketching / modelling / drawing / physical thinking / external memory / 'way of testing' / drawings, such as perspectives, sections, plans / ...

Table 2. Categories referring to the extent actions and skills of the design process are named.

Category	description
instruction	Giving explicit instructions in terms of ‘designerly' actions and skills. For example: come up with at least three different alternative concepts or ideas / come up with at least three different ways to solve this particular problem and study the (dis)advantages.
explained	Explaining the design processes, a design skill or set of activities. Clarifying how designers may approach, such as how to decide, coming up with different alternatives, and testing them. Relating the design products at hand to ‘designerly' thinking. Could be about one element or the relations between elements.
mentioned	The design process is named or referred to with one or a few terms or notions (see Table 1). Could be a synonym of an element or referring to an action ‘part of the element’. Often in the sense of “you should ...”, “you may ...”
not mentioned	The design process is implicitly present, in talking about the product at hand, mostly in the form of product-related examples or instances. No mentioning nor referring to notions and terms of the design process.

Results

The results will be described in three sub-sections. Firstly, some common features of a tutoring session will be given, relevant to understanding the research results in their context. Secondly, the data from the observations will be described per element, based on the sub questions: (1) Do teachers articulate the generic elements when they discuss design products with their students? (2) If so: to what extent do they articulate the elements of the design process? In the third sub section, the results regarding the third sub question are given: (3) What kind of expressions do they use?

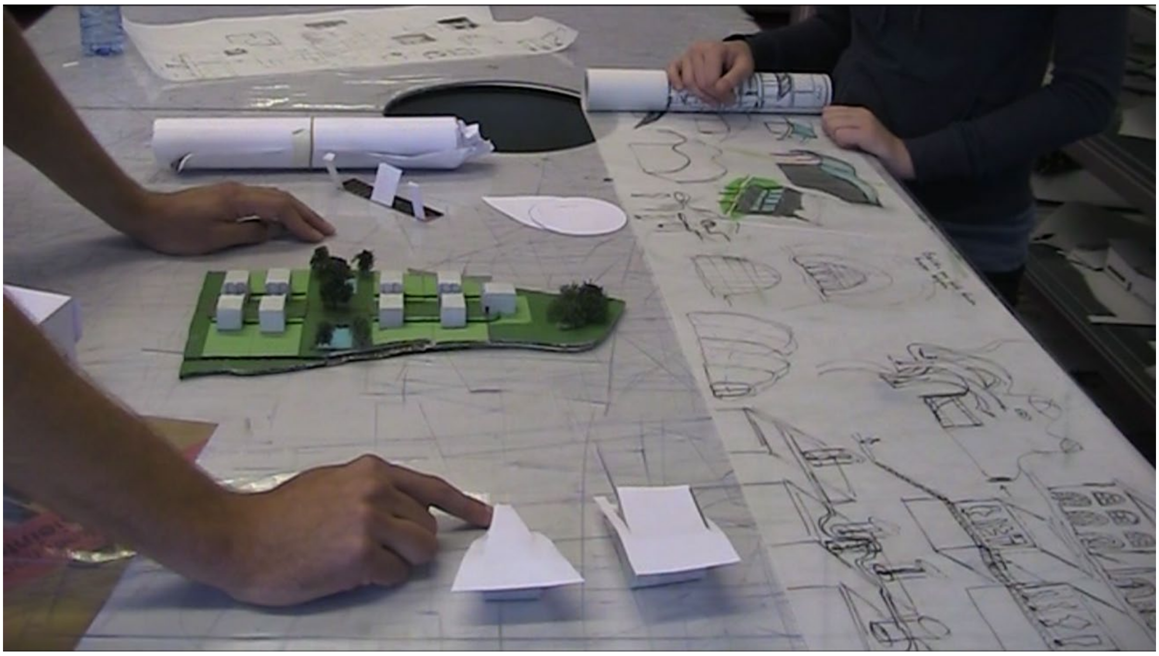

Figure 2. Dialogue between teacher and student in first year design project with models and sketches on the table.

Features tutorial dialogues

The observed dialogues mostly take twenty to twenty-five minutes, with some exceptions of three and forty minutes (see Figure 4). There seem to be no qualitative differences: discussions seem to be simply longer, consisting of more items or more time per item. On the table is the work of the student: sketches, drawings and models (see Figure 2). The amount differs between tutoring sessions; some students show a lot; some students show only few drawings and models. Two types of tutorial dialogues can be distinguished: (a) dialogues with a recognisable start in which the student talks about the project, ending approximately a third of the way through the tutorial in a 'turning point' from which the teacher takes over, and (b) dialogues without a recognisable start; the teacher reacts directly per item to what the student is telling. In all cases, the end of the tutoring is abrupt: it simply ends or a teacher just briefly repeats one of the discussed items.

In general, the discussion is on an 'aspect' level. Students describe the results of what they have done; they describe the product at hand. They talk about the living space, the entrance, and so on. For example, in the tutoring by teacher 3, the student starts by talking about the results of the work done in the past days. The story is descriptive, more or less about 'what is where' (see Table 3 - A1). Besides asking questions to understand what a student has done (see Table 3 - A2), teachers react on the project at hand and what the student has done with monologues and (rhetorical) questions. Parallel to the talking, some teachers sketch, showing what they mean at a visual level.

Table 3. Parts of the tutorial dialogue of teacher 03, with underlined sentences referring to the design process (translated from the original dialogue in Dutch).

	The design task at hand is a house plus studio for an artist. The discussion takes 22 minutes.	label
A	START TUTORING / EXAMPLES TEXT STUDENT	
The student starts telling about changes made in the design in the past days. The story is descriptive, about ‘what is where’.		
1	S: *I have also thought about changing these rooms: the dining room and the living space. But that didn’t work out with the kitchen. I want to have a separate kitchen. An open kitchen is good, but not functional.* S: *To make it quieter, I have made the living space over there. And I have made a longer wall here...* S: *In the living room is an opening in the wall; you can look into the studio.*	
The teacher is mainly trying to understand the drawings.		
2	T: *I’m lost; where are we?* T: *It is a beautiful drawing, but I don’t know… where are we, in what direction do we look?* T: *I try to analyse what you do. In fact, you make a house consisting of two parts. ... In the largest part you make a staircase.*	
B	MIDDLE TUTORING / EXAMPLES TEXT TEACHER	
The tutoring continues and is about the walls around the staircase and hallway downstairs and upstairs: they are not placed over each other. The teacher assumes there is a reason for it and the student explains:		

3a	S: *Here, I wanted to make a kind of mini-sculpture walk, with some tables over here, with sculptures on it.* T: *Look, now we are talking. What next? I should think; okay, I want to know …. This means that this staircase…. what is the size now?* S: *0,8 metre* T: *can it be wider?* S: *it may be also 1,0 metre* T: *if you want to make in fact room for exposition here.* S: *yes* T: *what does that mean? It means that the inhabitants and guests will see the art. Then there is the chance that the artist takes his visitors upstairs: 'Come, I want to show you some things'. So, it is not a hallway anymore, but it is more. Then, for me, it may have more space. What would that mean? What if you would say .. I am going to find this out. What does it mean, for your design?".* S: *my design?* T: *maybe the library would become a little bit smaller?* S: *Yes, but the sculptures will not be on the staircase ..* T: *No, but you can make the stair wider, making it more conspicuous."* S: *yes*.	experiment, mentioning
3b	T: *Making it more important. I understand that the sculptures are not on the stairs, but you may take more space […] What happens then?... Do things shift?...* [...] T: *What I try to say to you … that when you start designing, these small things may change your whole design. But in the end, it will be important… this is tough, because it is a lot of work to make this kind of beautiful drawings and then change them again. But… that's what being an architect is about... changing everything continuously. Until you think: this is how I want it to be*.	experiment, mentioning
The tutoring dialogue continues about symmetry in relation to the rooms and the way you walk through the house. Later on, the teacher also refers to making a load bearing wall and a column.		

4	T: *… that means that you have to make something like a column here. You may put it inside. So, you can make the facade the way you want it to be … but you have to do something. <u>You should look at the house of Lina Bo Bardi again.</u>* S: *Yes, but what should be the proportion of the column?* T: *The column may be 30 centimetres… like the walls … square or round, doesn't matter…* […]	frame of reference, not mentioning
The tutoring dialogue continues, mainly on a product level. The teacher jumps from one aspect to another, barely referring to the process, only:		
5	T: *<u>then the exploration is what you need..</u>.*	experiment, mentioned
Later on, the student asks how to explore:		
6	S: *yes… in fact I don't know how to explore further…* <u>T: *By drawing, drawing, drawing, … by asking yourself what you are doing?*</u>	experiment, not mentioned + laboratory, mentioned
C	END TUTORING / EXAMPLES TEXT TEACHER	
The tutoring ends with some sentences such as:		
7	T: *<u>it is all about making choices</u> […] <u>so: sections</u>. And make also a drawing of the house on the site. That is a first sketch of the garden, that is important.* *Okay? Good luck!*	experiment, mentioned

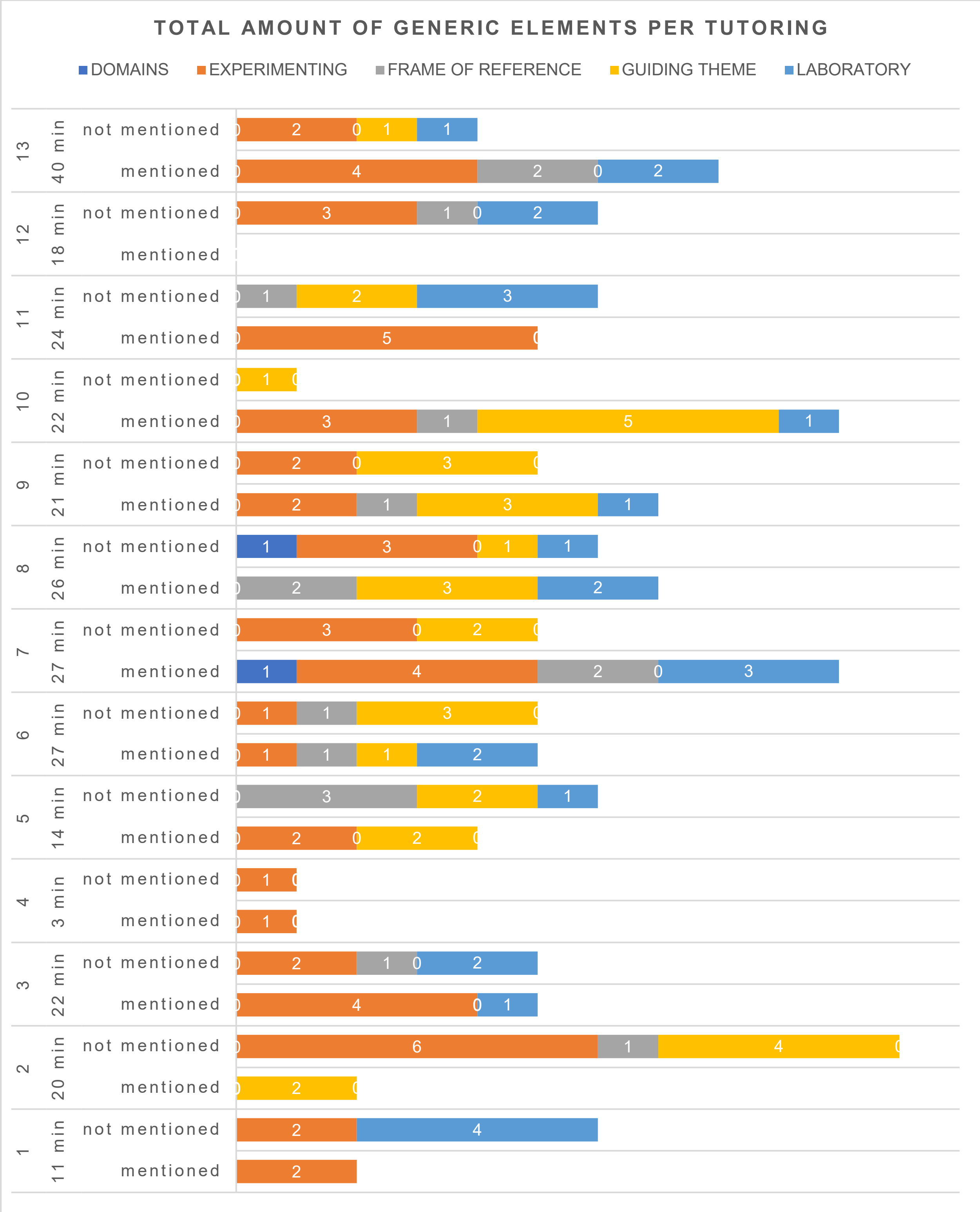

Figure 3. Number of times design-process elements are referred to during tutorial dia-logues and duration of tutorial dialogue in minutes per teacher.

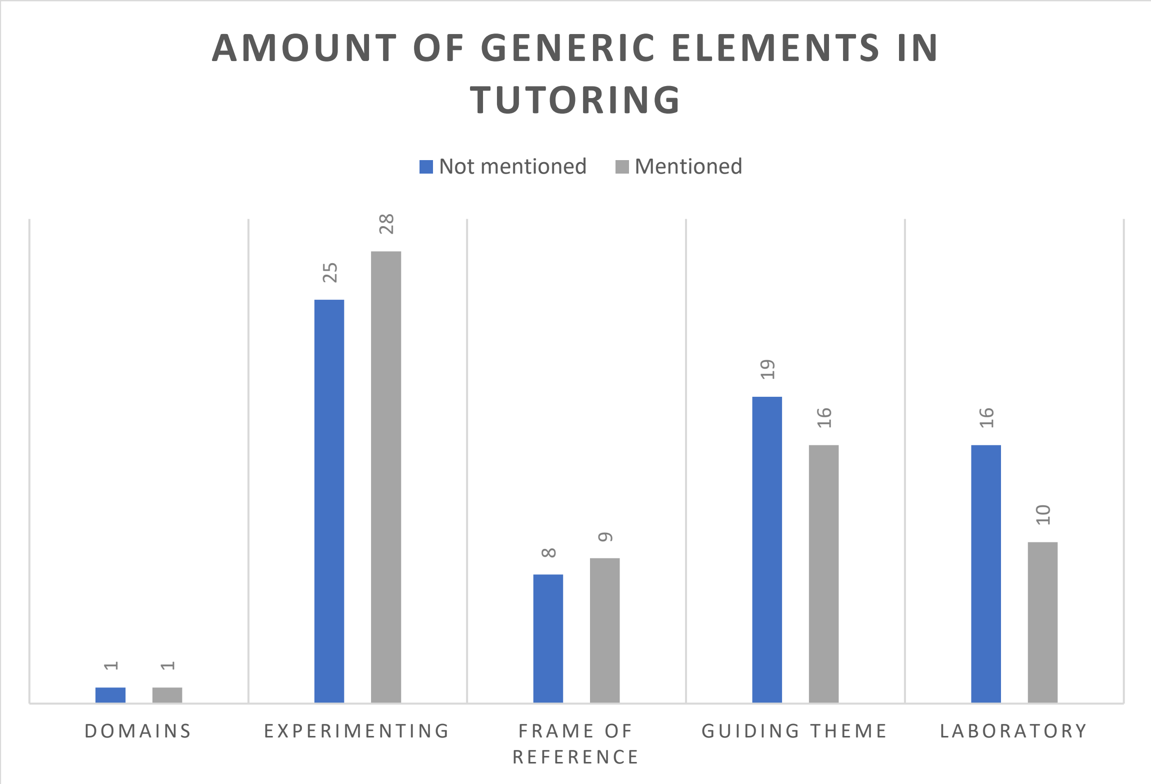

Figure 4. Total number of times design-process elements are referred to during tutorial dialogues: teachers give examples (not mentioning) or refer to (mention) notions in the design process.

Experimenting or exploring and deciding

Of all the elements, teachers referred most to the element of experimenting: n=53/133 in thirteen tutorial dialogues (see Figure 3 and 4). However, teachers did not explain the 'how and why' of experimenting, neither did they give instruction in this respect.

Teachers showed the process of experimenting by suggesting and talking about possible solutions of the particular design problem at hand (n=25 'not mentioned'). For example, a student tells teacher 04 that concerning an issue of the previous tutorial dialogue - transporting large pieces of art to and from the studio on top of the house - he will solve this problem with a lifting platform. The teacher reacts by saying that it is possible to use a platform *"being a large intervention [...] you may make a hoisting beam at the façade [...] or hire a crane each time you have to transport something [...] or use the staircase."* He mentions that the last two options are not so handy. Then he simply goes on with another item without a conclusion or explanation.

Teachers also refer to the element of experimenting by using notions, such as 'different solutions', 'studying', 'alternatives', 'exploring things', 'just doing', 'testing', 'finding out' and 'choices you have to make' (n=28 'mentioned'). They use sentences almost as a kind of side-remark, while talking about the design product. See for an example, table 3, part 3a.

In two quotes teachers give a glimpse of what experimenting actually means (coded as 'mentioned'). For example, see table 3, part 3b. And teacher 07 refers to testing (in combination with the element of laboratory): *"You need to test it. It is inventing or making and then testing if it is like that. (..) Testing is making or drawing. In making you may surprise yourself. …You cannot visualise everything, so your hands can do more than your mind. With a model it is the same, maybe you cut it the wrong way, but then it shows something, you may like".*

Guiding theme or qualities

Teachers also regularly refer to that what gives direction in the design process, a guiding theme or quality: n=35/133 in thirteen tutorial dialogues (see Figure 3 and 4). However, teachers do not explain the role of the guiding theme in relation to the product at hand, neither do they give instructions in this respect.

Teachers seem to refer to the process of giving direction by talking about possible aspects and moves regarding the particular design problem at hand (n=19 'not mentioned'). For example, teacher 11 seems to refer to how a designer may make a jump from a 'local' aspect to a theme for the entire design, without naming it: *"Instead of just using solar panels, you could consider finding out how to make the house as sustainable as possible? How can you make use of that in the architecture?"*

Teachers also refer more literally to the guiding theme, using a palette of names and notions, such as 'motives', 'starting points', 'dream images', the 'essential', that 'what gives surplus or value', 'the importance of doing something that distinguishes your design from another', 'key-point', 'strip down to the core', the 'value' of the design, a 'story', a 'bigger story' and 'setting priorities' (n=16 mentioned). They all seem to have their personal names or notions.

Teacher 08 refers to a 'starting point': *"A contrast between an 'underground' and a 'floating' volume. That may be visible in the materialisation. That it is clear that they are different, … a contrast, being two different functions in two different elements. […] two characters… [..] That may be a starting point as well: that you have two similar things, worked out entirely differently".*

Three times a glimpse of 'the how and why' of a guiding theme is given (coded 'mentioned'). Teacher 05 refers to a bigger story: *"What I hear you saying is, I have looked at the roof, I made a variant for the roof, I know about the entrance, but those are all small solutions. […] What I miss is a bigger story. So you could take all kinds of small actions … it is all possible… but what do you want to achieve in the end? [...] Well, you are the designer. You have to say: this is what I want. It's like having a 'steppingstone', that makes it easier to take decisions".* Teacher 09 refers to the quality in relation to making decisions: *"You may set priorities, for example, requirements that are essential for you, that may help you* *make decisions. If you make it all equal in value, it is hard to decide. If you say for example, it is about the dinner table, […] you may add quality by making a central space [..] Not everything has the same importance".* Teacher 10 seems to explain on a product level: *"Now you have to go to the key point, what is it that you want to achieve? So, you have to strip it down to the core, now. What is the most important?" […] I want to know what the core is. What do you want? […] Let's say you will present this to the brothers. They say they don't have the money. So you have to cut. Then it may become a slack extract of what you really wanted. So, from the start, you have to have a clear picture, so that you cannot miss what you want. […] It is not about the budget; we do not have a budget now. But it is about being aware of what you are doing".*

Domains

Throughout most of the tutoring sessions teachers refer to all kinds of aspects. Teachers and students talk a lot about aspects such as light, texture, colour, proportion, mass, composition, form, detail, structure, column, beam, span, experience space, function, and so on. The discussion is 'in' the domains, on a 'product-level'. However, teachers barely address the domains on the level of the design process. Only on rare occasions do teachers talk in a more abstract way about the aspects and scales and the relation between them, about how to work in and across the domains: n=2/133 in thirteen tutorial dialogues (see Figure 3 and 4).

Two quotes refer to the relation between aspects. Teacher 08 does this in the form of an example (n=1 not mentioned*): "Do you want the hallway over there or over there? Do you want to be surprised? That you enter a room with its own view? But that is related to the anchoring. To the location. And a feeling of holiday".*

In the other quote (teacher 07) a first glimpse of explanation can be seen (n=1 'mentioned'): *"You can look at a building from different points of view, so from shape, function, direction of the wind, location. […] The location, the view, the function and the dynamics of eventual facade panels, that those relations… In a good design it appears at a certain moment, that your choices will strengthen each other."*

Frame of reference or library of examples

Teachers refer to the frame of reference, to the professional principles and patterns designers work with: n=17/133 in 13 tutorial dialogues (see Figure 3 and 4). Teachers do not explain the role of references in the design process, nor in relation to the specific design product at hand. Neither do they give instructions on how to work with references.

Teachers refer to a reference project by simply mentioning its specific name (n=8 'not mentioned'). For example, teacher 10 simply refers to being inspired by an architectural type*: "It is good that you let the treehouse inspire you."* Teacher 08 refers to a specific item in a reference project: *"You had the teahouse of…"* (S:) *"Toyo Ito"* (T:) *"There is a large* *void, where downstairs and upstairs come together".* Teachers also refer literally to the frame of reference, using one of two notions: 'reference' or 'example'.

Solely in two quotes more is said about the reference projects: teachers 06 and 07 refer to the analysis of a reference. They do not mention what to do with it in the design at hand.

Laboratory or the language of sketching & modelling

Teachers address the process of sketching and modelling: n=26/133 in 13 tutorial dialogues (see Figure 3 and 4). They do not explain the role of sketching and modelling in the design process, nor do they give more instructions. Teachers refer to the laboratory with all kinds of sketches involved, such as drawings, sections, and plans (n=10 'not mentioned'). Teacher 03 says: *"You have to draw sections, you have drawn the facades well, now you have to draw the section".* Teachers also refer to the laboratory with the actions involved, such as sketching, modelling, drawing different times (n=16 'mentioned'). Teacher 01 says: *"Maybe you should think this over ... sketch what happens here"* and *"so, you have to sketch... different times. Roughly, as I do now. It does not have to be orderly"'*.

Because sketching and modelling are literally the laboratory for the process of experimenting, a direct relation can also be seen in the dialogues. For example, teacher 13 asks: *"Did you test that in a model?".*

Expressions used by the teachers

Exploring the way in which teachers talk, the open character is quite striking. Besides the obligatory statement: *'you have to ...'*, teachers let students decide what to do with what is said and how to do it. Teachers ask a lot of questions. For example, regarding the width of a staircase in relation to a place to show art (teacher 3): *"what is the size now?, "could it be wider?".* Furthermore they keep statements 'personal': *"What if you would say .. I am going to find this out"* (teacher 3*), "What is missing for me is a bigger story"* (teacher 05) and *"You may set priorities, for example, requirements which are essential to you, that may help you make decisions"* (teacher 09). When a student has made a choice regarding an aspect, it is regularly left open if it is a good choice or not. For example, in the example about the lifting platform mentioned earlier, new options are given when a student has come up with a solution, without discussing how to make the decision.

Conclusion and discussion

Regarding the first sub-question, in general teachers refer to elements in the design process several times in a tutoring session (see Figure 4). However, teachers refer to the design process (second sub-question) mainly in two ways: (1) implicit by using examples, directly related to the project at hand to show the process of designing, without mentioning or explaining the actions they 'model', and (2) literally to the design process by mentioning all kinds of notions, such as exploring, testing, variants, starting points and sketching. These notions have the character of side-remarks or footnotes, almost hidden in the discussion about the design product at hand. Teachers barely explain the design process. Only in five quotes (5 out of 133 quotes, teachers 03, 05, 07, 09, and 10), a first glimpse of making the design process more explicit can be seen. However, it is more a matter of justification than explanation. Therefore, they are labelled as 'mentioned'. None of the observed teachers gave explicit instructions. Regarding the kind of expressions (third sub-question), teachers mainly use questions and suggestions. They seem to leave the student to decide if and what to do with what the teacher has said: 'you can / may do that', 'for me, it is'. Even in the case of 'you have to', they do not explain the why and how of the mentioned action.

Answering the main question in this paper whether, to what extent and how teachers articulate the design process in architectural design education, we may conclude that it remains for a large part implicit. Overall, the tutoring is about all kinds of aspects involved in the design project at hand. Teachers talk with students about the position of the rooms, the form of the building, the position or measurements of a staircase, a view, the entrance, the composition of the facade, and all other kinds of aspects. Amongst this, teachers regularly mention design actions and skills in terms of 'you have to' or 'you may'. For example: they tell the student to explore, but they do not explain what they mean by that, how to explore in the particular situation at hand, and how it relates to ways designers generally explore.

Experienced designers may understand each other, however, for (novice) students this may be confusing. There may be a significant difference between what teachers mean and students understand, as Schön (1987) already illustrated with the 'drawing' example, mentioned above. Before discussing how teachers can make the design process explicit, first the limitations of the research will be discussed.

Limitations

In this paper, the articulation of the design process is literally the subject of research. However, as already mentioned in the introduction, tutoring in the studio is more than the text of the dialogue. Regularly, teachers and students refer to sketches, such as plans, sections, and models. In several cases teachers sketch parallel to their talking. Also, aspects such as body language and the atmosphere between teacher and student play a role. Together, these aspects could make the dialogue becoming more or less clear than only looking at the language and notions used.

One could justifiably argue that the design process should not be articulated in all tutorial dialogues. However, in thirteen randomly chosen observations in the first design project of the architectural design program, one may expect the design process to be explicitly articulated more often than it actually was. This should also be the case if the process is subject in other courses. Being subject in parallel courses *and* in the design studio, helps bridge the gap between theory and practice.

In principle, the results of the case study presented here are not proof for other design school situations. However, recorded in different contexts and with different research approaches, the results presented here seem to run parallel to the results presented by Schön (1983, 1985, 1987), Dinham (1987b), Uluoğlu, 2000, and Goldschmidt, Hochman and Dafni (2010), which supports the generalisation of our findings.

Other limitations to the study presented here, are natural implications of the chosen research method: the process of recording and coding. Teachers may be affected by the presence of a camera. Furthermore, the number of labels per element may still be a point of discussion. However, these decisions do not interfere with the main conclusion. Only five quotes were topic of serious discussion, being on the border of being explicit. In fact, these quotes are an extensive way of mentioning, a kind of description what may happen in the design process. They do not explain the design process.

Making the design process explicit

In the process of analysing and labelling the framework helped in comparing what actually is said and what can be said seen from the perspective of the design process.

For example, in the dialogue about the staircase with some sculptures (see Table 3), teacher 03 starts to ask if the stair may be wider. The student ('yes, 20 cm') seems to interpret it as a matter of measurement, being a first-year student without a large frame of reference. The teacher seems to 'pull' the student to the idea of a 'function exceeding staircase' and concludes about small things which may change the whole design, "that's what being an architect is about changing everything continuously. Until you think: this is how I want it to be." To avoid misinterpretations, to give an overview and to explain design process actions, it could be discussed more directly, such as: the staircase as (1) a functional staircase, (2) a staircase with room for having some pieces of art, (3) making the staircase as an art gallery, as the core of the house, or (4) making the house 'living in a loft-like art gallery'. Each with its (dis)advantages and its own specific proper means to achieve it. This way the student gains an overview and logic of architectural ideas, such as qualities or themes (e.g. house as art gallery) and architectural means, such as principles and patterns (e.g. enclosed staircase and hallway with rooms or a staircase in an open 'loft' space, each with corresponding constructional principles). The student still has to choose, but the teacher now articulates the kinds of choices and how these choices are related. This example seems to run parallel to the way teachers mainly seem to tutor their students: reacting 'afterwards', discussing all kind of aspects of the design product at hand.

However, studio and tutorial dialogues may also be structured according to the 'designerly' actions and skills, to train students 'automatically' in the way designers think and act. First year students may be given small tasks as part of the whole design task, such as coming up with three themes or qualities next time, or coming up with alternative solutions and means to develop the preferred theme. For example; regarding the lifting platform the teacher might have given in the previous tutoring the instruction to study different methods of transporting objects vertically in reference projects, presenting them in diagrams or icons and reflecting on them in the situation at hand.

To conclude: teachers barely articulate the how and why of the design process in general, and in connection with the development of the design product at hand. They do not relate the situation at hand to the larger context of the design process. As educational practice proves, students may learn how to design simply as a result of doing design tasks and discussing the products at hand with their teachers – even when the design process stays implicit. However, making the design process explicit can significantly enrich and speed up their learning process (Kirschner, Sweller & Clark, 2006; Van Merriënboer & Kirschner, 2018). Students may experience learning-how-to-design as less confusing, they may in the long term become better designers, they may spend their time in education more effectively, and their self-confidence may increase. With the help of a design vocabulary teachers should be able to talk about the design process and train students in a more explicit way.

Next research steps will be testing the framework in design education. Does it help teachers in being more explicit and in organising design education? And even more important, does it help students in mastering the confusion and become more successful designers?

Acknowledgement

A lot of thanks to all teachers and students, being so kind to do the tutorials before a camera.

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Evaluation of strategies of creativity development used in store design projects based on student projects

Seval Özgel Felek, Ordu University, Turkey

Özge Gül, Dogus University, Turkey

Abstract

The aim of this research is to search and find strategies of creativity in teaching in the interior architecture design studio. There are lots of ways for training architects all over the world, instructors find their own way and style. Most design education, also architectural design, occurs through the studio system. Design studios embed project-based learning in most universities, and have been adapted as a teaching-learning strategy by the instructor in this study. Developing creative ideas has been a part of architecture design studios. Creativity is one of the basic constituents of innovation, and innovation is described as ‘applied creativity in the field of design education’. Hargreaves (2000) suggests that “you can have creativity without innovation, but you cannot have innovation without creativity”. The role of the instructors is to lead the students, understand and encourage them to create alternative design solutions. Meanwhile instructors show how to design and develop creativity in this process.

This article presents the methodology, processes, and outcomes of creativity strategies implemented during the process of producing alternative plans into a Store design project carried out as part of the Design Studio II class in a Turkish University. The strategies "Dead Head Deadline" and "Merged Ideas in a Box and Circle of Opportunity" are intended to expand students' perspectives, train them to propose solutions they would not have considered and, prevent them from fixating on a single idea. They also support them in creating freely. Feedback received from students after the implementation of these strategies is also presented in this research.

Keywords

design Studio, Architectural Education, Interior Architecture, Store Design, Creativity Strategies, Implementation Project

Introduction

Creativity is a matter of concern for every profession, for students of architecture it is particularly relevant. Architectural students need creativity both in the university and in business life. They should learn and experience creativity in projects developed in university. It is therefore critical that techniques and strategies be taught to develop creativity skills in undergraduate architectural programmes. In the first section of the article, literature studies related to creativity in design studios is given. In the second section of the article, implementation studies and recommended strategies are given.

Creativity in the Design Studio

This article specifically focuses on creativity in design studios. Design studios are the general names of design-oriented courses in architecture education. This section contains a literature review of studies in this field. Denomination of creativity depends on the discipline; it is called 'innovation' in education, 'entrepreneurship' in business, 'problem solving' in mathematics, and 'performance' or 'composition' in music. Creative products of various fields are measured according to the norms of their field based on their own rules, approaches, and concepts of creativity (Reid and Petocz, 2004).

There are many reasons for students to improve their creativity. In recent years, the most developed countries have been switching from industrial economies to information economies. The principal aspect of an information economy is innovation or psychological and educational creativity. If a country wants to compete in global economy, the curriculum should be a revised to involve creativity and innovation (Costantino, Kellam, Cramond and Crowder, 2010).

Creativity in the design process occurs when an important event, often called 'creative step', emerges. Sometimes such an event can be grasped suddenly by the designer, but often occurs when the designer can identify the steps in the design process (Dorst and Cross, 2001). Dealing with design problems requires creativity other than knowledge and expertise. Creative thinking requires the perception of a problem or event from a new perspective outside of the usual. Designers use different kinds of principles, tools, and heuristics to improve their creativity (Casakin and Kreitler, 2005). How creativity can be assessed in individuals is also an important issue. In order to accurately demonstrate creativity, it is necessary to approach the concept of creativity in terms of creative person, creative process and creative product. It is seen that the first studies on the measurement of creativity were based on the 1950s and were based on the investigations of J. P. Guilford. Guildford (1981) identified creativity with four main factors that were put into practice to assess individual creativity. These four factors are elaboration (amount of detail in the responses), innovation (statistical uncommonness of the responses), fluency (quantity of appropriate responses), and flexibility (variety of categories of appropriate responses). These four factors are very important and often taken into account when assessing individual creativity in different areas of problem solving. For this reason, they are seen to have high relevance to the design field. Increasing creativity requires looking at events, behaviors, and objects differently, seeing behind the scenes, and requiring being open to diversity. Creativity is to see the piece (detail) within a whole and also to see the whole within the piece (Çelek, 2011).

The design studio is the most important, complicated and difficult experience students go through in current design education. In a design studio, students are asked to understand several new concepts and ideas as well as perform two tasks, namely to design and to learn how to design, simultaneously. Also, students should establish personal relationships with other students and learn new techniques and skills (Sachs, 1999). The process of critique and the design studio is not only a lesson but also social interaction between students and the instructor and among the students themselves. In a way, communication is a keyword in the definition of a design studio (Demirbas and Demirkan, 2003). Students create alternative design solutions in the design process. Students brainstorm with different ideas and suggestions to evaluate design proposals while taking into consideration critique of the instructor in this process (Lawson, 2006).

In higher education, instructors should understand their role is not to teach students to be historians or designers but to be learners. Effective learning appears to be the key not only to success in education but also in a fast-moving working environment. One reason design students have difficulty conceptualizing and theorizing is because they are uncomfortable with this learning style (Ashton, 2010). As istructors we are asking students to engage in a strategy of learning in which they are not skilled. The learning preferences of design students, as we might expect, are action-oriented and revolve around imagination and emotion. Most design students have been steeped in these approaches even before they arrive in higher education. However, the vital stages of assimilating and comprehending our actions require us to be logical and thoughtful. Kolb (1984) believes that a balance of all these aspects is desirable, but he recognizes that people from various disciplines will have different learning styles, indeed these will have been developed in the course of their education. A change is needed to long-established learning habits, students should be encouraged to develop new strategies so that they have a pool of appropriate strategies from which to select.

Design instructors are supposed to constantly develop their teaching strategies and pedagogy to emphasize successful approaches to designing and thinking in a problem solving (Travis, 2011). Even very talented students generally feel that they have no control over the design process and that they fear it. This teaches students how to design and constitutes one of the most difficult challenges for a design studio instructor (Ledewitz, 2014).

The ‘Design Studio’ process can be mysterious for first-year students. Indeed, what the instructor wants the students to do may not be very clear. However, the instructor cannot really explain the situation until the students start the process, which can only be understood from the inside. Therefore, the instructor cannot have a dialogue with the students until the student lays the foundation for the first response to the problem. Schön (1987) describes this process as reflection in action, and the design studio as telling and listening, and demonstrating and imitating. The instructor can organize activities with the students and the process depends on the instructor's ability to create a game environment. Although the literature on architecture education contains no information on how to create such an environment between the instructor and the students, lessons can be drawn from psychoanalytic experiences (Schön, 1987).

Instead of having a single language and a single understanding, the instructor should be able to objectively look at the different approaches of the student. It is necessary to prevent the possibility that the result is the design of the instructor and the designer is the copy of the instructor. For this reason, the instructor may want to try different approaches to the design during certain periods. In this context, the instructor should never compromise, encourage synthesis to seek students, seek different ideas and contrary possibilities. It must be the student who makes the choice and the decision (Şahinler, 2000).

Instructors should give reliable clues for students to look for better strategies or solutions, urging them to find better ideas rather than compelling them towards a certain idea. They should not destroy the design ideas students present at one swoop. The role of an instructor is to understand and consider the proposals of students, and to contribute to the development of their design ideas (Yürekli, 2007).

Due to the complexity of the design process, there are no precise and complicated formulas that combine forms, functions, contexts and available technologies. Adhering to a mentality dominated by principles, experiences and intuitions, most designers achieve design solutions heuristically, i.e., cognitively (Kowaltowski, Bianchi and Teixeira de Paiva, 2010). Designer creativity depends on the personality type. Intuition is at the core of designer creativity. Designers can choose to play games as they generate ideas and the resulting ideas may sometimes be ridiculous or funny (Durling, Cross and Johnson, 1996).

According to Eigbeona (2013) several authors like Stevens, (2002), Morrow, et al. (2004), Holloway, (2013) and Thompson, (2013) have all found the importance of creativity in the training of architects. The following strategies that may foster or stimulate creative thinking in teaching the architecture design studio:

> *(1) Restrictions – building codes, site conditions, costs, etc. (2) Brainstorming (3) Analogy/ies (4) Removing mental blocks (5) Tools - like CAD (6) Techniques - like drawing/drafting technique (7) Protocols of good practice (8) Structure - good structure of design problems (9) Cognitive - cognitive thinking (10) Philosophy - philosophy of design strategies (11) Research (12) Theories of Architecture (13) Synecticts (14) Morphological Charts (15) Criticism (16) Historical Drawing (17) Model making (18) Attribute Listing (19) Axiomatic design strategy (20) Bio-Mimeticry (21) Browsing (22) Precedents (23) Architectural Values (24) Charrettes (25) Component Detailing (26) Doodling (27) Testing activities (28) Exaggeration (29) Excursions (30) First Principle (31) Focus/Focus Groups (32) Mind Mapping (33) Other Peoples Viewpoints (34) TRIZ (35) Think Tank (36) Using Crazy Ideas (37) Using Experts (38) Visual Brainstorming (39) Visualizing a Goal, (40) Doing Sketches (41) Working with Dreams and Images (42) Repertoire learning (43) Computer screens (44) The Creative Pause (45) Outputs (46) Chanllenge (47) Alternatives (48) The Concept Fan (49) Concepts (50) Provocations/Setting Up Provocations (51) Movement (52) Phototyping (53) The Random Input (54) Sensitizing Techniques (55)*

Visualizing a Goal (56) And having a critical knowledge and application of structures, materials, colours, light, shadow, lines, planes, masses, space, etc., can result to creativity too (Asasoglu, A. 2010 et al).

As seen, different strategies could be used for stimulating creativity in teaching design studios. This research sets out to investigate different strategies.

Implementation project

Scope of the Study

Two strategy studies were carried out as part of the Design Studio II course of the Interior Architecture and Environmental Design Department of the Faculty of Fine Arts at Istanbul Gelisim University in Turkey, in the spring term of 2017/2018 to examine the approaches to develop the creativity of Interior Architecture and Environmental Design undergraduate students in design studio classes and evaluate the contribution of proposed strategies in the process.

Firstly, information is given about methods to increase creativity. These studies were carried out individually in the pre-sketch phase and in a two-week period. The student group consisted of 13 people between the ages of 19 and 21. The average age was 19.46 and standard deviation was 0.66. There were three male and 10 female students in the group and participation was voluntary. The research design studio was held in the third and fourth weeks of the course. Participants were given information on the study, then signed consent for the study were obtained.

It is important to introduce creative approaches to inexperienced students in the design studio. Teaching students the principles of good design and how to develop creativity should be taught in this process. The role of the instructor in the studio environment (teaching, directing, showing, supporting, provoking, discussing) is vitally important (Yürekli, 2003). The role of the instructor is to act as a guide who supports the autonomy and initiative of students rather than being the sole source and transmitter of the theoretical knowledge. The obligations of the instructor can be explained as "selecting activities, putting students into activities, arranging problem situations, acting like a catalyst, and producing divergent solutions of students" (Bevevino, Dengel and Adams, 1999).

VanGundy (2004) was examined in terms of strategies that could be applied in design studios. It is known from previous experiences that students have difficulties while creating alternatives of general arrangement. It was observed that they were not creative when they were asked to produce ideas quickly, especially within a certain time limit. It was decided that the ‘Dead Head Deadline’ strategy would be suggested as a solution for this problem. Another problem identified by Van Grundy was that students became stuck in a single idea and had difficulty in producing alternatives. They were hesitant when they were asked to sketch on paper, even though the ideas were ridiculous. This method was created to make students see the ideas they have in mind or the students never thought about. ‘Merged Ideas in a Box and Circle of Opportunity’ strategy was created by combining two strategies as a solution for this problem. Different ideas will be created with the “Ideas in a Box” method. And with the "Circle of Opportunity" method, they will leave the choice among these ideas to chance. Two strategies suitable to be implemented in this project sketch phase of the design studio were chosen. Each of these approaches are discussed with study results in the following two sections.

The "Dead Head Deadline" Strategy and Its Adaptation to the Design Studio

Midterm submission deadlines in design studio classes were determined and an attempt made to familiarize students with this process. The in-class process was also managed by setting deadlines for the course. People live in a world of deadlines and are constantly ordered to do things now, do yesterday, do soon, and simply, do. Instructors, must prepare students for this world. They must show them if a job is not done now, it will never be done. Having deadlines is oftern though of negatively, but does have positive aspects. Deadlines can be used to be more creative. These deadlines can give the motivation needed to boost creative productivity (VanGundy, 2004).

In this study, a store design project was carried out with students. The first two weeks consisted of observation, research, determining brand identity, and presentations. In the third week, the students were asked to design alternative layouts on the plan provided for them. However, it was observed that students could not come up with different ideas and were blocked. As explained in Section 1, they were afraid at the stage of producing ideas, their development hindered by the fear of making mistakes. It was explained to the students that there were no wrong ideas, and they should try creating. The instructors could not advance the process until the students initiated it. The necessity to turn this process into a game was also explained in the initial phase. Ching (2006) sees drawing as the most natural and even instinctual human need. He also argues that drawing is an instrument of vision and expression, making ideas visible and which acts as thoughts of visual imagination. He mentions that the act of drawing is a natural reaction every human can perform and does not require special talent. Therefore, in the first strategy "Dead Head Deadline" the students were asked to produce alternative layouts, logical or illogical, even ridiculous, racing against time. As instructors, every student struggled to sketch and be comfortable with expressing their ideas.

With this strategy the deadline and tasks must be realistic. A decision was made with students on how many sketches should be produced in how many minutes. The process was designed to be realistic, no longer than necessary, and productive. At this stage, the Pomodoro technique, which was invented by Italian student Francesco Cirillo in the 1980s and was still studied, was included in the strategy. In this technique, Cirillo set 25 minutes for work and a 5-minute break, based on the idea that the mind works more productively in shorter time intervals. The time limit was intended to maximized concentration on a single task to help the mind focus on a single matter with maximum efficiency. Brief breaks after work function as rewards for achievement, and increase motivation (Cirillo, 2006). It was decided that students would use bubble diagrams for 25 minutes to quickly prepare 15 sketches of general layout plans. Denel (1979) defines creativity as proposing multiple solutions in a brief period. Based on this perspective, time was started, and it was seen how many sketches students prepared within 25 minutes. Then, the instructors and students examined the sketches and separated the ones that presented solutions. To facilitate the task a two-storied store plan was given to the as shown in Figure 1.

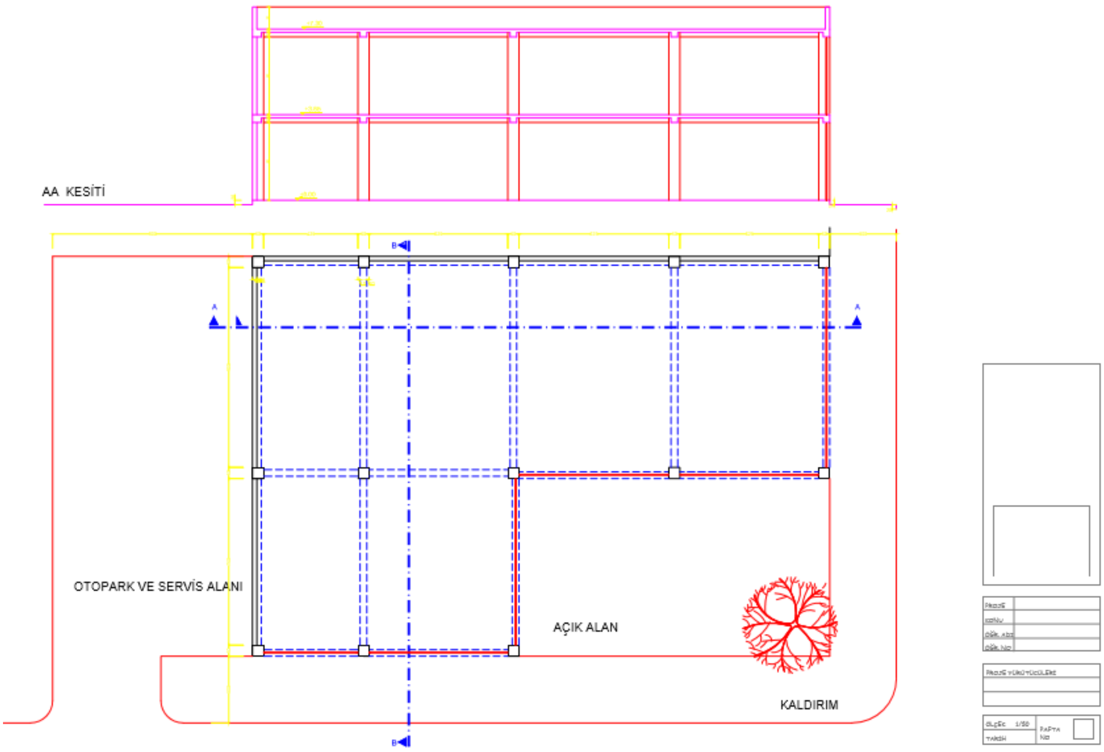


Figure 1. Design Studio Store Design Project Plan

Work from two selected students are presented in this article. Figure 2 shows the work of applied “Dead Head Deadline” for Student 1, who prepared 10 sketches in the time interval. Alternative layout plans created by applying ‘Dead Head Deadline” strategy by student 2, who prepared 16 sketches in the time interval, are presented in Figure 3.

With this strategy, students can see how many different ideas they can produce without separating right or wrong. Previously, students couldn’t decide what to do during the eight hours of course duration. But now, they saw how they could be efficient in a short time period. Deadlines are stressful situations in both work and student life. They saw deadlines has a positive contribution. So, they transformed the time constraint into a motivating and creative action.

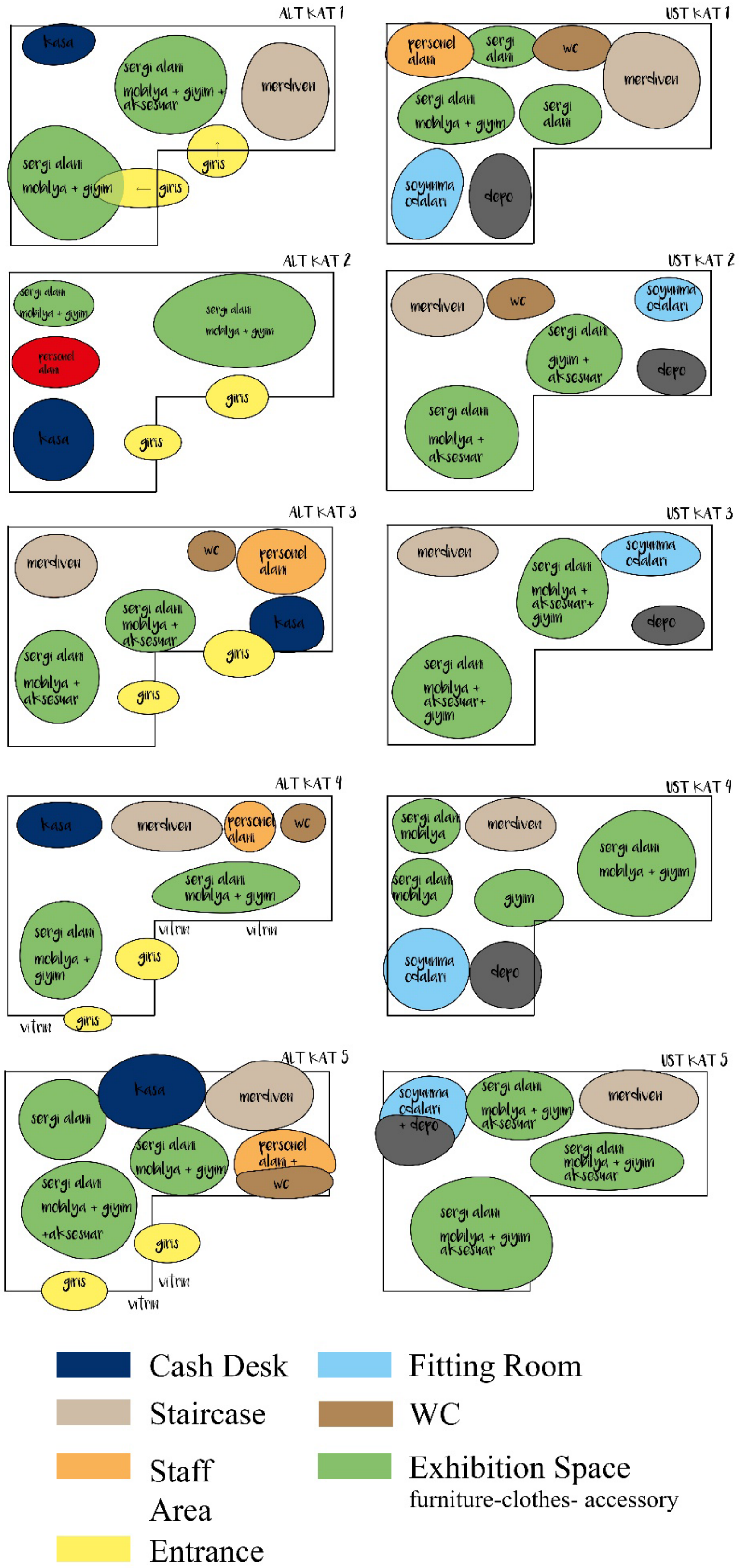


Figure 2. Student Sketches – Student 1

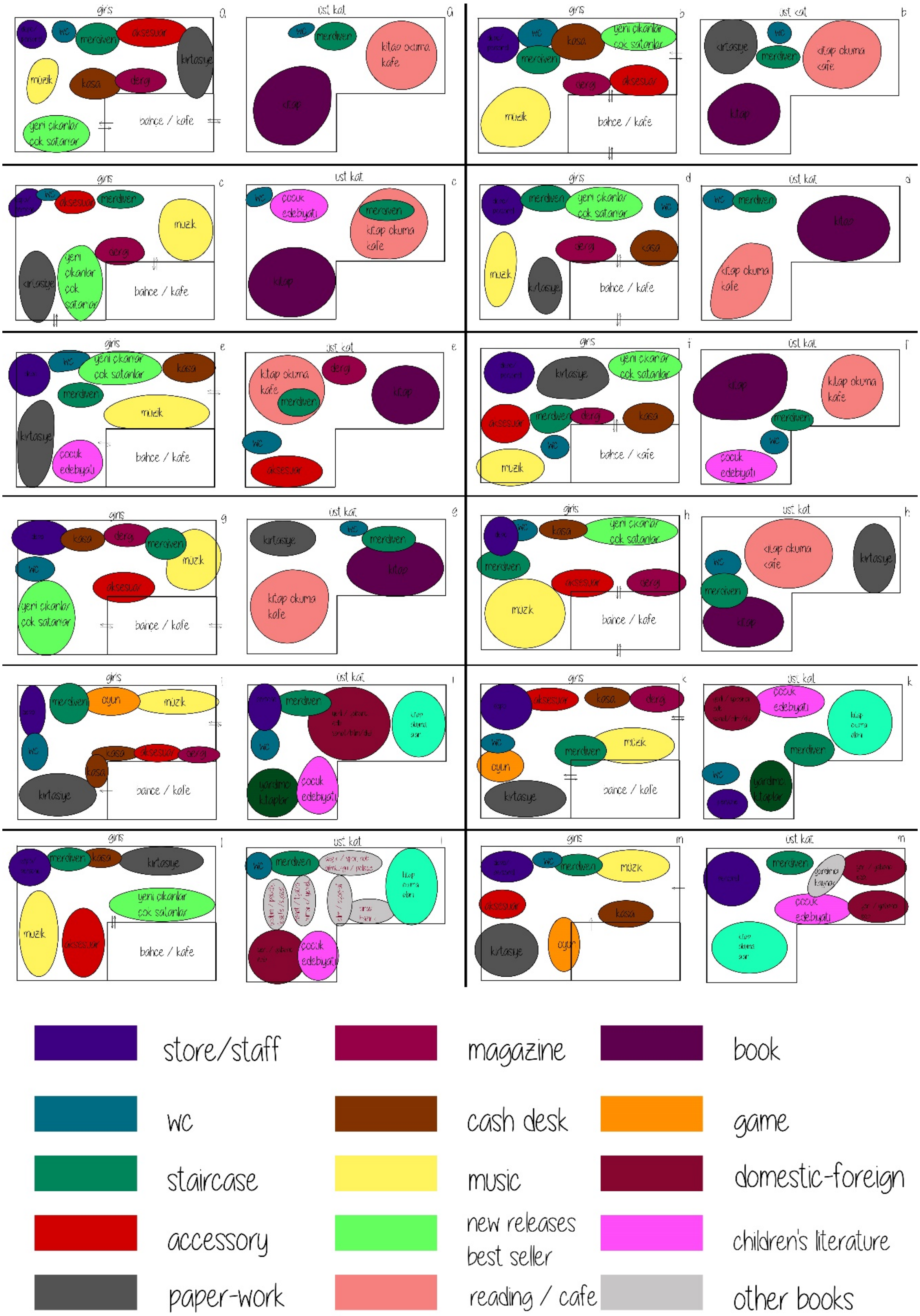
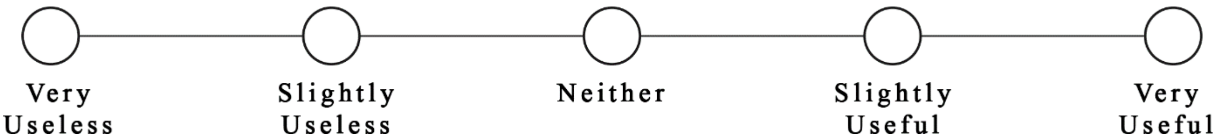


Figure 3. Student Sketches – student 2a. Evaluate the strategy in terms of creation of alternative layout plans.

A survey was conducted after the application and students evaluated the strategy. They were asked whether they considered the process to be beneficial and whether they would use this strategy later. A Likert scale was used in the questionnaire. The Likert scale is one of the most popular (and reliable) ways to measure someone's attitudes and behaviors. The Likert scale measures attitudes and behaviors by using varying response options from one end to the other (ie from the least likely to the most unlikely). Contrary to a simple "yes / no" question, the Likert scale allows you to expose ideas. This can be particularly useful for sensitive or challenging topics. For this reason, in addition to the evaluation questionnaire prepared by the five point Likert scale, also there are two open questions. The aim was to express the opinions of students with open questions. Results from both sets of data are presented in the next section.

a. Evaluate the strategy in terms of creation of alternative layout plans



Seven of the 13 participating students found the application very useful and six found it slightly useful; so, 53% found it very useful, and 47% found it useful.

b. Was the strategy challenging for you? Explain.

The aim was to create 15 sketches within 25 minutes. It is observed that 10 sketches were successful in this time interval. The limit, which was higher than necessary, yielded successful results as it challenged the students. Seven of the 13 participating students said it was not challenging, four said it was slightly challenging and two said it was challenging but the challenge was beneficial for them. Therefore, the strategy did not challenge 53% of the students, slightly challenged 31% of the students and challenged but was beneficial for 26% of the students. The students who were not challenged said the time limit helped them creating more ideas.

c. Would you use this strategy in your other projects?

When asked whether they would use the strategy in other projects, 10 said they would use it, two said they would use it and one said they would maybe use it. 77% of the students said they would use the strategy later, 15% said they would definitely use it and 8% said they would maybe use it.

According to Ching, there are two routes in drawing activities. The first, observation-based drawing, is to capture, understand and remember the moment. The second, imagination-based drawing, helps us communicate with what is in our minds, and this process is crucial for design. We can coordinate what we think and our hands only by drawing (Ching, 2006).

This strategy was implemented to pouring ideas quickly onto paper while establishing this coordination.

The "Merged Ideas in a Box and Circle of Opportunity" Strategy and Its Adaptation to the Design Studio

"Ideas in a Box", originally known as morphological analysis or matrix analysis, was developed by Fritz Zwicy in 1969 to help create scientific ideas. Like in other combined activities, it drives ideas by forcing the combination of problems that lead to new ideas (VanGundy, 2004). This exercise offers a relatively systematic way to consider different idea variations. On the other hand, it can be limited as it emphasizes seemingly unrelated matters. However, it is a fitting exercise for people who want to analyze situations. To carry out this exercise, it is necessary to categorize a problem into sub-problems and create alternatives for these sub-problems. The strategy is intended to help inspire new ideas by combining alternatives.

The strategy was applied to the store design project. The person inside the store space is in a position to feel the presence of the inhabitant in order to become a spectator. Through the atmosphere created in the store, the person perceives the bounded space. For this reason, the editing of the space is very important. Often a consumer's first impression of the store depends on the things that can be seen or felt from outside the store; showcase, the size of the store, the architectural structure. Depending on these factors, they may make a judgment. The store atmosphere is a broad concept that extends from outside to inside, ranging from product exhibition display regulations to lighting and decoration (Bayçu and Arslan, 2016). Within the scope of the design studio, all these items are referred to preliminary preparations. In this article, the process of creating general layout plans is mentioned.

After the rough design of general layout plans, they were categorized into subunits, for which layout alternatives were designed. The strategy was proposed because students had a difficult time creating alternatives and could not make progress. The students were asked to create many layout alternatives; however, it was observed that they were fixated on one or two alternatives. It is necessary to show students that alternatives they did not consider could work, and it is intended to find creative alternatives by turning the process into game. As instructors, our task is to encourage them to create multiple ideas.

It was necessary to categorize a problem into sub-problems to use this strategy. This stage was carried out by brainstorming with all the students. Based on the importance of creativity, initially Osborn (1957) proposed "brain storm" strategy. Brainstorming in general a probable strategy that accommodates many possible solutions (Sutton and Hargadon, 1996). Brainstorming is a strategy of developing thinking skills and creativity in individuals. This strategy also improves the ability to solve problems in individuals and to produce solutions to the problems faced. Individuals develop skills during training and learning periods, not only by themselves, but in group work by producing ideas and listening to the opinions of the group members and building from these ideas (Rawlinson and Broudy, 1976). According to Osborn, the quality and quantity of the ideas produced can be enhanced by the brainstorming technique. The quality of ideas increase as well, however participant should refrain from criticising individual thoughts. Diehl and Stroebe (1987) found a high relationship between the number of thoughts and the originalality of thoughts. The important thing is to produce many thoughts thus increasing the likelihood that an original idea will emerge.

In this study the main ideas affecting the store layout plan was determined as presented in Figure 5 as they, with subheadings, were written on a workshop board. These were the formal layout plan, the stairs, accessories/elements and the impact on design. For the formal layout plan, grid plan and open plan Berman-Evans classification, were chosen. Store plan diagrams are categorized into five types: the straight plan, the pathway plan, the diagonal plan, the curved plan and the geometric plan (Özdemir, 2014). Considering these two classifications and according to the layout plans of the examples examined at the design studio, the layout plan was divided into subheadings like the grid system, the curvilinear system, diagonal, geometric form and mixed system, as shown in Figure 4.

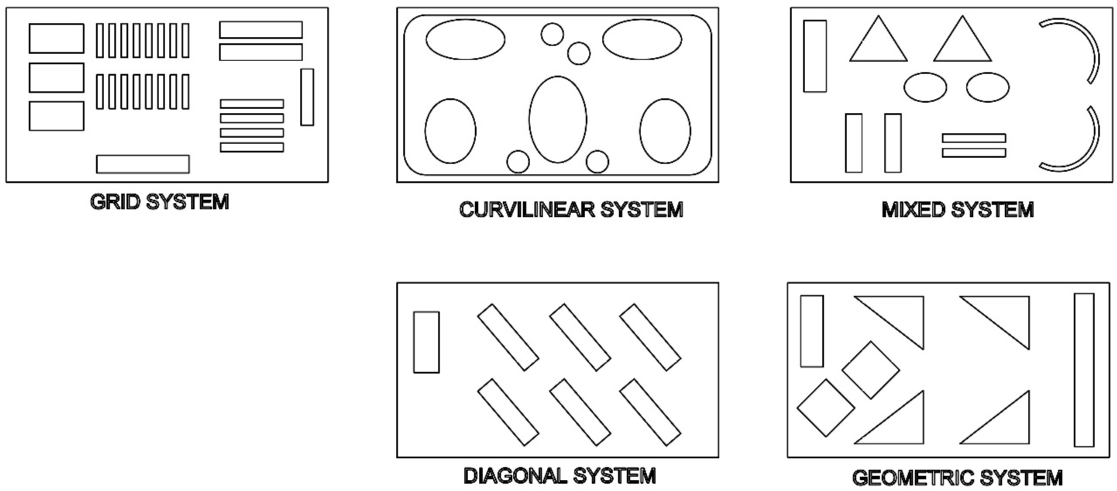


Figure 4. Layout Plan Subheadings

The grid plan has a solid layout, which we can also call the grid layout; the size, shape, length of the corridors and width of the display areas show a homogeneous distribution throughout the entire store. This arrangement allows the customer to access the back side of the store. Compared to other types of in-store placement schemes, it is the most efficient in using store space. Clear and evident corridors facilitate shopping. It creates a clean and tidy store atmosphere. It allows customers to choose the products themselves. It also facilitates stocking, labeling, cleaning-maintenance operations (Lewison, 1997).

The free plan allows for a lower systematization but a different use of equipment according to the grid layout. It allows creative visual presentations, encourages unplanned shopping as it facilitates instant purchase and passage between departments. Also, they have a flexible layout, the stores can enlarge, reduce, or change the parts they want without distorting the overall internal layout (Levy and Weitz, 2001).

Also shown in Figure 4, construction of the curvilinear system plan type is more difficult and economically more costly than other plan schemes. The curves are emphasized by shaped walls, ceiling and corner points. In such spaces, suitable equipment is used for the curves of the space in circular form.

There is an angular pedestrian flow originating from the diagonal system sequence. The angled arrangement provides an interesting environment design. This can wake up the feeling of excitement when visiting the space. The geometric form system has a schematic diagram that is shaped by geometric forms with showcases, shelves, and angled walls elements. Within the space, the customer provides a different environment (Barr, 2003).

Mixed system is formed by using plan types together. Another floor can be created by using a different plan type while a certain floor type is used with a plan type, and it can also be created by applying different plan types in different sections within the same floor.

The staircase main heading was divided into the subheadings of straight, turning left, turning right, two-handed and spiral staircase types. The accessories and elements of the store were divided into subheadings like entrance, showcase, register, changing rooms, stairs, ceiling, floor, walls, and exhibition elements. Interior impact to be emphasized was chosen to be chaotic, natural, luxury, calm, peaceful, light and intimate based on the brainstorm.

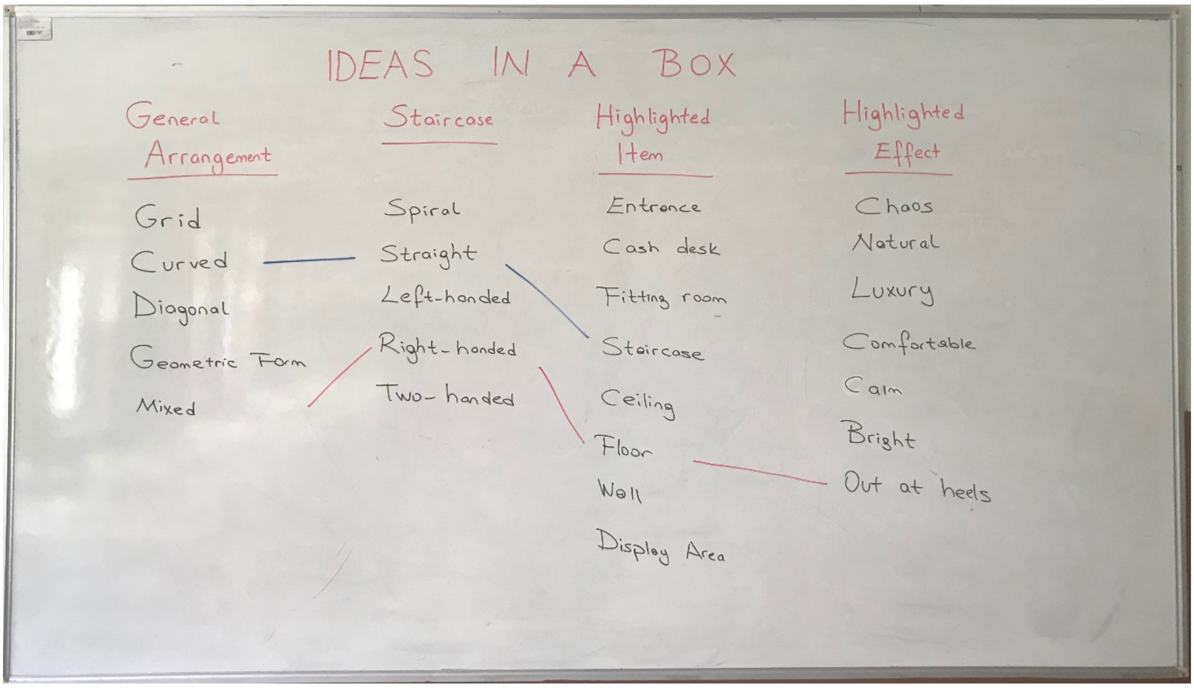


Figure 5. Implementation of the "Ideas in a box" strategy at the workshop

The students were asked to write the subheadings on the forms provided for them. There was a debate on which alternatives should be matched to generate an alternative layout plan. At this stage, it was observed that the students were inclined to choose the items that fitted the plan in their imagination. The "Circle of Opportunity" strategy was integrated to support the students' imagination by helping them created alternatives they did not want or consider. The "Circle of Opportunity" strategy was likened to gambling. All creative activities are described as gambling in this strategy. It is known that we use our time, efforts and creative skills in a process that we cannot foresee, and for all our efforts, we can sometimes make things worse. All types of gambling include an element of chance, which leads to interesting things. Chance determines whether we win or lose, and we can utilize it even if we cannot control coincidences. For instance, we can use the random to help advance ideas. Random combinations of the characteristics of a problem can evoke new ideas (VanGundy, 2004). Therefore, the combinations of alternatives were turned into gambling to transform the process into a game, in which students had fun and control over the process was completely randomized. The two main headings were tested at the first stage. Subheadings of the formal layout plan and the stairs were written on paper in two groups. Items were drawn from the first and second main headings, and the students were asked to match the results on paper. At the second stage, they could choose from a main and subheadings themselves and were asked to created alternatives with as many draws as they want.

The students were interviewed one by one and selected from the function charts they created with the help of the “Dead Head Deadline” strategy in the previous week. The second strategy mentioned in this section, “Merged Ideas in a Box and Circle of Opportunity” strategy, was introduced to create layout alternatives based on selected function diagrams. A one hour period is given for each of the settlement plans to reflect the path implemented by using this strategy. The alternative samples emerged at the end of the period are shared below.

Evaluation of the Sketches

Sketch examples based on the draws from two main headings belong to Student 1, Student 3 and Student 4 are presented below. Figure 6 shows that Student 3 created a mixed layout plan with a spiral staircase, and a grid system layout plan with a straight staircase.

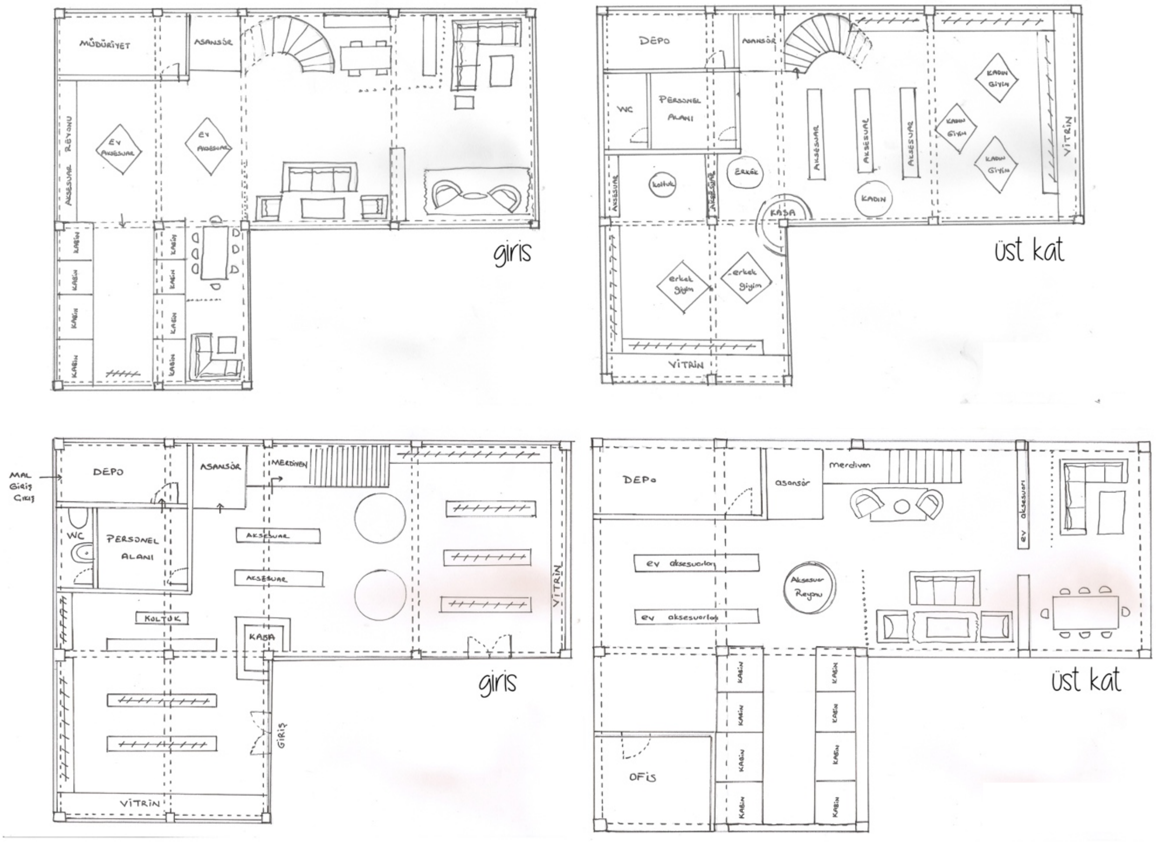


Figure 6. Student Sketches -Student 3

Figure 7 shows Student 1 based her alternative on a mixed layout plan and a two-hand staircase.

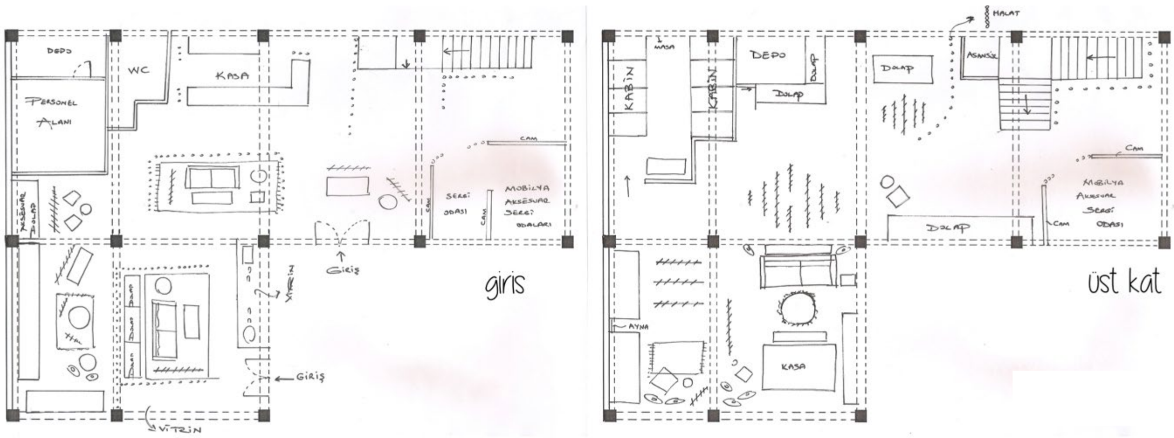


Figure 7. Student Sketches 2- Student 1

The layout plan in Figure 8 was created by Student 4 who based her choices on the four main headings: a grid system with a staircase turning right, and the ceiling as the emphasized element and the impact of peace.

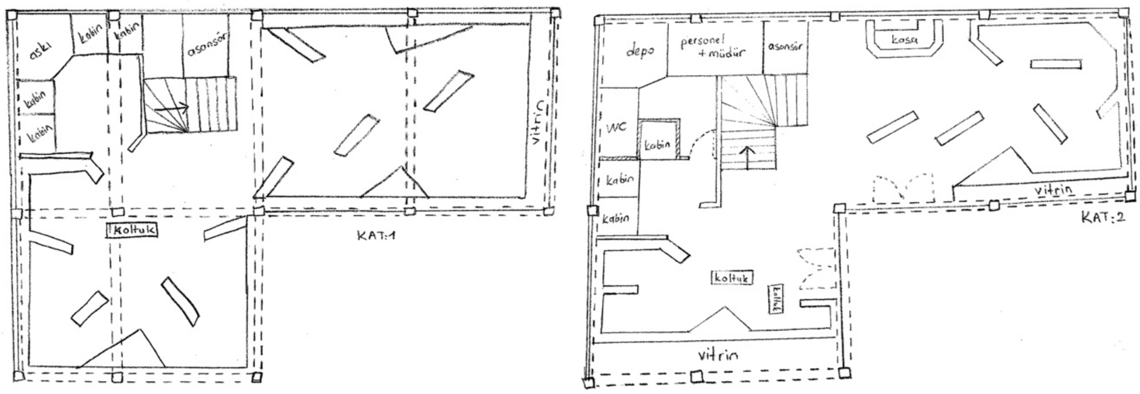
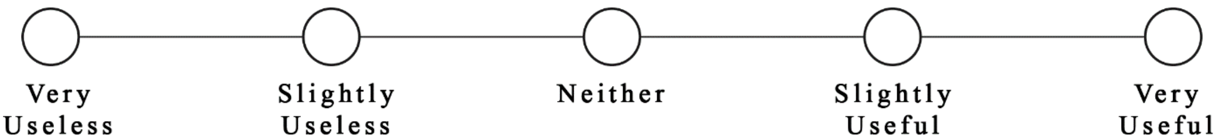


Figure 8. Student Sketches 2- Student 4

Student Evaluation of the Strategy

A survey was conducted after the application, and the 10 participating students evaluated the strategy. They were asked whether they considered the process to be beneficial and whether they will use this strategy later. As in the "Dead Head Deadline" strategy, the evaluation questionnaire includes an evaluation question prepared with a five point Likert scale, as well as two open questions. The aim was to express the opinions of students with open questions.

a. Evaluate the strategy in creation of alternative layout plans.



Four of the 10 participating students found the application very useful, five found it slightly useful, and one was neither; so, 50% found it very useful, 40% found it slightly useful, and 10% was neither.

b. Was the strategy challenging for you? Explain.

Among the 10 participant students, three said the strategy was challenging but beneficial for them, two said it was slightly challenging and five said it was not challenging. So, 50% of the students were not challenged, 20% was slightly challenged and 30% was challenged but finding the strategy beneficial. The comment of one student exemplified how the strategy achieved its goal: "Even thought the strategy challenged me in the beginning, it showed me a lot about what I should do. I used ideas I never considered thanks to this strategy and achieved positive results."

c. Would you use this strategy in your other projects?

When asked whether they would use the strategy in other projects, one said they would definitely use it and nine said they would use it. 90% of the students said they would use the strategy later, 10% said they would definitely use it.

Conclusion

Design studios in interior architecture are carried out by feedback or critique between the instructor and the student. The instructor explains the subject to the students, and either presents them with a prepared plan or asks the students to find a plan they would want to study. Function diagrams are formed by means of observation, research, making intervies, determing the needs and presenting the current situations. Students attempt to create alternative plans and ideas based on the selected funcition diagram. During this process, the project is built on the ongoing critique between the students and the instructor. Students should attempt to determine their own priorities and critique themselves rather than develop a project to meet the instructor's wishes. Therefore, students need to be creative throughout the process. Some projects can be rendered completely functional, produced and applied; however, projects lacking in creativity would have a hard time gaining recognition and influence in the sector. Creativity must be developed and supported, especially in students. Various strategies are recommended to help students improved their creativity in design studios.

In this study, potential contributions of creativity development strategies for students in design studio classes were evaluated. "Dead Head Deadline" and "Merged Ideas in a Box and Circle of Opportunity" strategies were applied in the book titled "101 Activities for Teaching Creativity and Problem Solving" written by Vangundy (2004). Students are asked to create function diagrams in the third week of their project. In the fourth week, they formed general arrangement plans based on the selected alternatives from the proposed function diagrams. It is observed that they have difficulty in developing creative solutions by thinking for a long time while creating functional diagrams and layout plan alternatives. With these two proposed strategies, they have been able to create solutions quickly, and have seen that alternatives that are not in their minds can offer solutions before they get stuck in a single idea.

After the exercises, the progress students made with the strategies were examined and the students were asked to give feedback Through the use of the strategies, various stimuli were included in the process, aiming to help Design Studio II students who were inexperienced and struggling to emerge strong and creative with their store design ideas. Based on the study, implementation of various strategies to boost student creativity during the process of creating layout alternatives is seen as beneficial. Student feedback confirmed this. In design studios, students are encouraged to improve creative thinking in their education, and these strategies give students a structure that can be maintained in their professional lives. Most of the students reached the conclusion that the strategies were useful in terms of creativity, researching in different subjects and gaining versatile thinking skills. Most of the students stated that they also thought they would use the strategies in future studies. Therefore it would seem to be advantageous for instructors to exert efforts to study and test various strategies to improve student creativity. This article explores two specific strategies, contributions of other strategies in this process can be analyzed in further studies.

Acknowledgments

The authors would like to thank the ICM 252 -Design Studio II students of the Department of Interior Architecture and Enviromental Design at Istanbul Gelisim University in Turkey who contributed to this study with their designs.

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The Evaluation of the Relationship between the Use of Multi-Software and the Students' Attitude towards Computers and Technology in Undergraduate Architectural Design Studio Education

Asli Agirbas, Department of Architecture, Fatih Sultan Mehmet Vakif University, Istanbul, Turkey

Abstract

Different computer programs used in the architectural design process serve different purposes. However, the number of computer programs used is increasing at a rate that designers find it difficult to adapt to. Accordingly, the possibility arises to use more than one computer program during the architectural design process, and it is important to make the correct choice of which ones are most appropriate to use. This is also true for undergraduate students of architecture, and hence a pilot study was made, which focused on the use of multi-software within the scope of the architectural design studio. The relationship between the students' use of multi-software and their attitude toward computer and technology was evaluated statistically, by means of Pearson product moment correlations. The results showed that the attitude of the students toward computers and technology influences how they use multi-software.

Keywords

use of multi-software, architectural education, architectural design studio, computer attitude.

Introduction

Every passing day, new computer software emerges in the field of architecture, each of which serves different purposes. According to common usage purposes, it is possible to categorize such new computer software as Building Information Modeling (BIM), programs for free-form 3D modeling, programs for sustainable building design simulations and programs for making presentations. In addition, there are a number of programs for more specific purposes (such as acoustics, structural analysis, optimizations). BIM programs (Revit, Archicad, Allplan) are mostly used for the construction of projects, while programs such as Rhino, Grasshopper, Dynamo and Maya are mostly used for free-form 3D modeling experiments. Programs such as Ecotect, Velux Daylight Visualizer, EnergyPlus, eQuest, Daysim, Dialux and Grasshopper add-ons, for example Honeybee, Ladybug are also programs that are used for sustainable building design. Programs such as Photoshop, Illustrator and Indesign are mostly used for presentations. Programs such as 3d max, Maya, Lumion, and After Effects are also used for presentations, but are especially preferred for rendering and creating video. Examples of programs used for specific purposes are Grasshopper add-ons. For example, among Grasshopper add-ons, *Pachyderm* is used for acoustic simulation, *Karamba* is used for structural analysis, and *Octopus* is used for multi-objective optimization. Therefore, more than one kind of software is emerging for use in design education (Senyapili & Bozdag, 2012).

It is inevitable that computers are used in every modern undergraduate design programme, and from now into the future, the strategic use of computers will be essential, and this brings in the use of multiple software packages. The aim of the present study was to evaluate any relationship between the use of multi-software and the attitude of the student toward using computers, and therefore, a case study was made which focused on the use of multi-software within the architectural design studio course, as taken by students of the department of architecture. The students were directed to those computer programs that were considered to be most appropriate in the architectural design studio course, according to their particular design requirements. Thus, having experienced the use of many different programs simultaneously, the students were able to achieve appropriate results. At the end of the study, a questionnaire was conducted among the student group, to test the hypothesis that their positive attitude towards computer related technology encourages them to use multi-software.

Literature review

Many studies have been made to investigate the attitude of students towards using computers in the field of education. These studies have typically involved a search for a relationship between the attitude of the students toward using computers and factors such as anxiety over mathematical aspects, their prior experience with computers, cognitive ability, the influence of their teacher(s), personal characteristics and gender differences (Dambrot, Watkins-Malek, Silling, Marshall, & Garver, 1985; Smith, 1986; Miura, 1987; Levin & Gordon, 1989; Sigurdsson, 1991; Arthur & Olson, 1991; Gattiker & Hlavka, 1992; Shashaani, 1993; Francis, 1993; Jones & Clark, 1994; Robertson, Calder, Fung, Jones, & O'Shea, 1995; Shashaani, 1997; Mitra, Lenzmeier, Steffensmeier, Avon, Qu, & Hazen, 2000; Ames, 2003). Specific studies of possible connections between the students' attitude towards the use of computers in the design process, and teacher influence, and gender difference have been made (Hanna & Barber, 2001; Basa & Senyapili, 2005; Pektas & Erkip, 2006). A variety of studies have also been carried out on the computational approach in design education (Oxman, 1999; Cuff, 2001; Knight & Stiny, 2001; Ozkar, 2007; Oxman, 2008; Aish & Hanna, 2017; Oxman, 2017).

There have been many studies made on the methodology used for architectural design studio education, among which, Kolb's (1984) experimental learning model is widely used. Kolb's (1984) model is also used in various design disciplines (Kvan & Jia, 2005; Demirkan & Demirbas, 2008; Yavuzcan & Sahin, 2017). In this model, which is used in most of the architectural design studio courses, the approach of 'learning by doing' is in the foreground. Kolb (1984) describes the learning process as a cycle, in which four dimensions (concrete experience, abstract conceptualization, active experimentation, reflective observation) are defined (Fry, Ketteridge, & Marshall, 2009). Also, in this 'learning by doing' process, students refine and revise their ideas by means of sketches (Graves, 1977; Schon, 1983; Goel, 1992; Schon & Wiggins, 1992; Garner, 1992; Goel, 1995; Suwa & Tversky, 1996; Do, Gross, Neiman & Zimring, 2001; Do, 2002).

Methodology

This work was carried out within the scope of the architectural design studio course (in the second semester of the second year) given by the author in the department of architecture of the university where this study was conducted. The course was one semester long (14 weeks/ two days in a week). The tutor met with students on an individual basis and feedback was given to them about their work. In addition to this critique, the students were provided with information related to the computer programs that they used, or might use according to how their projects had progressed.

In the present study, a methodology was followed based on Kolb's (1984) experimental learning model, and in addition, the tutor's redirection on the use of the computer program was included as an input. With this methodology, the main effort of the student concerns the use of the computer program, which he/she uses in cooperation with the tutor in the design process (again with the 'learning by doing' principle). Due to the fact that there are many commercial computer programs available, it was necessary to limit the time taken to choose the particular computer program that the students will choose for their work, thus, achieving good time management. However, the likelihood that the student will discover alternative new computer programs as a result of their own research is accordingly reduced.

Before taking this architectural design studio course, the students had already learned the rules for architectural technical drawing, and experienced designing a single building size residence (or a similar design), independently from its periphery in the two architectural design studio courses and other compulsory courses. The students were asked to make a contextual design within the context of the architectural design studio used in this study, which involved first analysing the area they were provided with, followed by determining the deficiencies of this area, according to which they made suggestions of the building(s) that are appropriate for the area. While analysing the region, students were expected to make various site analyses, which may involve an analysis of the storey heights of the buildings, functional features, building materials, façades, historical buildings and special buildings (Caniggia & Maffei, 2001), green areas, parks and squares (Sitte, 1889), urban nodes (Lynch, 1960), topographic perspectives, solids-voids (Trancik, 1986), road patterns, transportation aspects, accessibility details, urban pattern (Koskof, 1991; Moudon, 1997; Panerai, Castex, Depaule, & Samuels. 2004), historical urban pattern formation (Petruccioli, 2007), social and cultural aspects, soundscape (Schafer, 1994; Ge & Hokao, 2005; Irvine, Devine-Wright, Payne, Fuller, Painter & Gaston 2009; Leus, 2011) and smellscape (Henshaw, 2014). Having done this, the students were expected to determine the site of their proposed buildings based on the particular features that they had defined. An appropriate choice of buildings, which collectively provide many different functions (such as library, public education centre, outpatient clinic, school, kindergarten, sports hall, exhibition centre, museum, youth centre) and the establishment of a good relationship between them are also expected. Ideally, all of the buildings should cover an area of 1000-1500 m2.

Since the content of compulsory computer-aided design courses that students have taken in the past years varies, the software that they know and use also varies. However, practically all students, who took the courses, are familiar with Photoshop, Sketchup and Rhino. In the architectural design studio in the content of this study, the instructor encouraged the students to use different computer programs for particular purposes. In the end of the studio course, many products have been produced with the use of different software. In this paper, an evaluation was made of the projects of 3 students who had been given grades above 80/100, along with the software that they used.

A questionnaire study was conducted with 13 students who took the course, in order to test the hypothesis that the students' attitude toward to computer and technology encourages the use of multi-software (Table 1). The questionnaire was completed online in the final lesson of the course semester, in order to prevent any communication between the students, who were also given sufficient time and advance information to complete the questionnaire; they were further informed that their identity would be kept anonymous, with the intention to obtain more realistic responses. The students answered all the questions thoroughly.

A 5-point Likert scale was used for the questionnaire. The answer option for each question in the survey was as following: Strongly disagree = 1, Disagree = 2, Undecided = 3, Agree = 4 and Strongly agree = 5. The questionnaire was categorized into "Students' attitude towards computer & technology" and "Students' attitude towards multi-software use" and covers 6 questions in total. The questions in the category of "Students attitude towards computer & technology" are as follows: "I want to learn more computer programs", "I find computers and technology exciting", and "I'm learning computers and technology just because I have to learn". It is planned to measure the degree of interest of students in computer and technology from the answers given to these questions. The questions in the category of "Students attitude towards multi-software use" are as follows: "I frequently make the transition between programs in design studio projects", "I have difficulties making transition between computer programs", and "Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose". In the responses given to these questions, it is planned to measure whether the student uses more than one program, if any problems are encountered in making the transition between the programs, and the choice of the computer program made for the particular purpose.

To measure the relationship between variables in the above two categories, Pearson product moment correlations (test of significance: two-tailed) were performed, using the SPSS statistical software. Then, according to the values obtained as a result of this correlation, the evaluation was made. However, it should be noted that the questionnaire was conducted with only 13 students, so the results obtained from this case study are somewhat limited. For more accurate results and larger generalizations, it is necessary to conduct surveys with a greater number students, and as taken from different universities.

Students' attitude towards computer & technology	I want to learn more computer programs I find computers and technology exciting I'm learning computers and technology just because I have to learn.
Students' attitude toward multi-software use	I frequently make the transition between programs in design studio projects. I have difficulties making transition between computer programs. Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose.

Table 1. The questions of the questionnaire

Results of the questionnaire

It turned out that all of the students wanted to learn more computer programs, since they found computers and technology exciting. However, some of them seem to show some reluctance according to an attitude of "I'm learning computers and technology just because I have to learn". Moreover, the result is that all students use more than one type of software in their project and thus made transitions between them. It turned out that the majority of students also think that it is better to choose a program for a particular purpose than to learn how to use a given program in great detail. However, it is seen that some students have difficulty in making transitions between the programs (Table 2)

There is a significant correlation between "I want to learn more computer programs" and "Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose”. There is also a significant correlation between “I find computers and technology exciting” and “Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose”. In addition, there is a significant correlation between “I'm learning computers and technology just because I have to learn” and “I have difficulties making transition between computer programs” (Table 3). That is, the hypothesis: students are interested in computer and technology encourages the use of multi-software is correct. In addition, the viewpoint of the student about the use of computers becomes effective in overcoming the difficulties of using multi software.

	Strongly disagree (number of persons / per cent)	Disagree	Undecided	Agree	Strongly agree
I want to learn more computer programs	-	-	-	1 (7.7%)	12 (92.3%)
I find computers and technology exciting	-	-	-	6 (46.2%)	7 (53.8%)
I'm learning computers and technology just because I have to learn.	6 (46.2%)	5 (38.5%)	2 (15.4%)	-	-
I frequently make the transition between programs in design studio projects.	-	-	-	1 (7.7%)	12 (92.3%)
I have difficulties making transition between computer programs.	2 (15.4%)	4 (30.8%)	4 (30.8%)	3 (23.1%)	-
Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose.	-	1(7.7%)	1 (7.7%)	5 (38.5%)	6 (46.2%)

Table 2. Percentage of the results of questionnaire study

		I want to learn more computer programs	I find computers and technology exciting	I'm learning computers and technology just because I have to learn.
I frequently make the transition between programs in design studio projects.	Pearson Correlation	-0.083	0.312	0.277
	Sig. (2-tailed)	0.787	0.300	0.360
I have difficulties making transition between computer programs.	Pearson Correlation	0.177	0.414	.687**
	Sig. (2-tailed)	0.563	0.159	0.010
Instead of using a program very well, I think that it is a better way to choose the program to be used, which is oriented to the purpose.	Pearson Correlation	.723**	.587*	0.350
	Sig. (2-tailed)	0.005	0.035	0.241

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3. Results of Pearson product moment correlations between "Students' attitude towards computer & technology" and "Students' attitude toward multi-software use" categories

The use of multi-sofware in architectural design studio

In this section, first, the best 3 student projects which had scored a grade above 80/100 were chosen for evaluation by the author. Various criteria for grading in the content of the architectural design studio course are as follows; development of designs within contextual design framework, having a strong concept of design, preliminary research / analysis, correct technical drawing, space organization of the created building designs, modification of the projects to overcome various obstacles encountered in the design process.

Case 1: Sports Centre Project

The student primarily conducted field research. At this stage, the municipal maps of the area prepared in AutoCad environment were transformed into a Photoshop environment and converted into analysis boards, which displayed the current situation in the region. The field research made it possible to visualize the missing qualities in the region, which therefore helped the student to determine the particular function to be proposed. Later, the student, proposed to build a sport complex by bringing an additional function to the stadium in the land next to it. To start the design, the student first began to make 3D sketches using the SketchUp program for the specific area that he had selected in the region. At this stage, the student actually entered the process of rediscovering with digital sketches, while simultaneously beginning to produce the site model. The student began to produce triangular shaped masses, starting from the form of the land and the concept of linking nodes in the surrounding field. The student had foreseen that after the design had reached a certain level, he would continue to design in Revit on the basis that this program could be used most easily to make sections, elevations and plans for anticipated triangular forms. The student brought these triangular forms into the Revit environment as mass and began to detail these mass models in the Revit environment (Figure 1), where the design process continued over an appreciable time. Once the design had been brought to a certain level in the Revit environment, the instructor recommended the student to also make energy simulations in Revit. Later, the student transformed the 3D model from the Revit to the Lumion environment, where he took renders and made an animation of the project, finally using the Photoshop environment for his presentation. This involved collecting into Photoshop the renderings in Lumion, plans, sections, elevation and perspectives obtained in Revit environment and map drawings in AutoCad, and finally creating the boards in Photoshop environment.

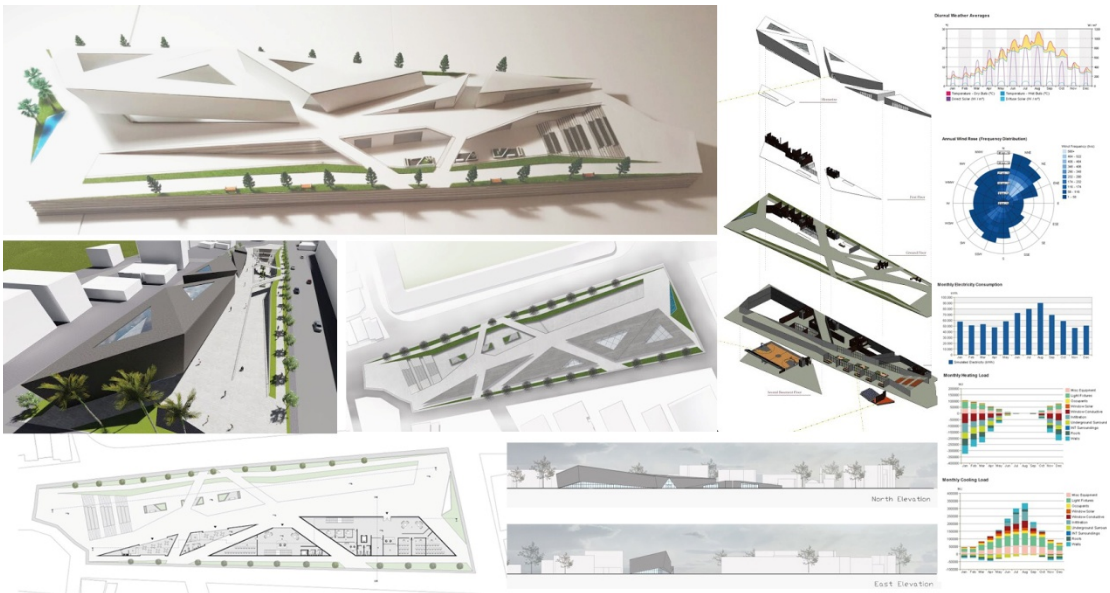

Figure 1. Sports centre study of a student

Case 2: Cultural Hub Project

The student primarily conducted field research, for which Photoshop and AutoCad programs were used. By considering the multiculturalism of the area, the student proposed a combined complex for young people, where many activities can co-exist.

The sketches were started in a 3D design environment and then most of the design time was spent in the Rhino environment, while simultaneously making the model/maquette studies (4). In addition, the student started to compete for creating differences on building facades after making decisions about the general mass. For this, he proposed a solid-void ratio that varies on the facade. To achieve this, a script was developed by using the Grasshopper program, which works as a plug-in to the Rhino program. Given the student’s interest in kinetic structures, and to reflect this on the facade, he suggested the possibility of making kinetic sun breakers, for which Arduino and Firefly (Grasshopper add-on) programs were used. At this stage, ready-made codes in the internet environment proved beneficial (Figure 2). For the presentation, he collected his model, drawings and various analyses in boards, by means of Photoshop.

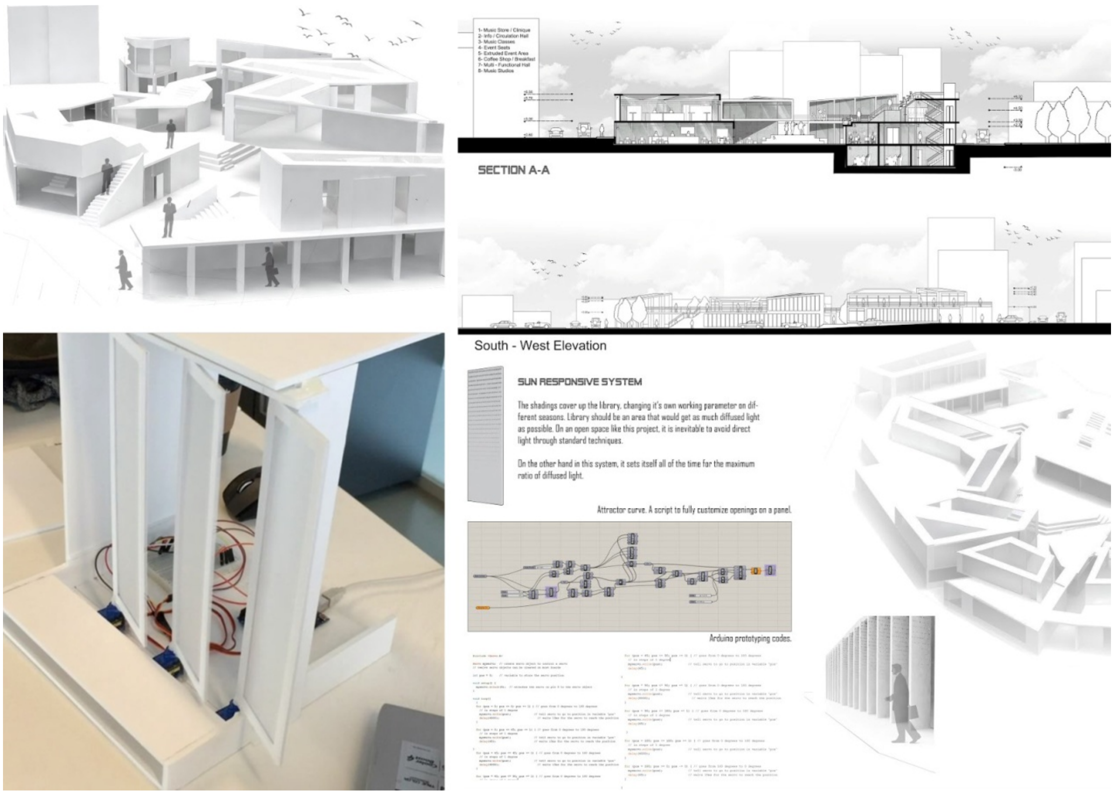

Figure 2. Cultural hub study of a student

Case 3: Public Library Project

The student focused on street pattern while making site analyses, for which a visibility graph of the region was obtained by means of the space syntax method, using the DepthmapX program. Based on this analysis, a specific area was selected for the public library proposal. The SketchUp program was used while creating a design mass model; however, the student simultaneously continued to draw plans in the AutoCAD program and made models/maquettes. Meanwhile, she also made transformations from AutoCad to SketchUp. After the building design had reached a certain degree, the student wanted to create a difference on the facade of the building in order to change its overall simplicity, for which the instructor recommended the use of the Grasshopper program. Since Grasshopper works as a plug-in to the Rhino program, the student transferred the 3D model that had been created in SketchUp to Rhino, by which means various facade trials became visible (created in Grasshopper with Voronoi geometry) on the 3D model in Rhino. In order to establish harmony between the roof of the building and the created facade on a form basis, various trails related to the roof were continued in the Rhino environment. Again, the student preferred to take a render in the Rhino environment. Facades (created in the 3D environment) were transferred to AutoCAD in order to reflect them in the elevations. Plan, section and elevations, which were prepared in AutoCad environment, were transferred to Illustrator environment to adjust the line thicknesses and these were transferred to the Photoshop environment in order to colour drawings. The last boards were prepared in the Photoshop environment (Figure 3).

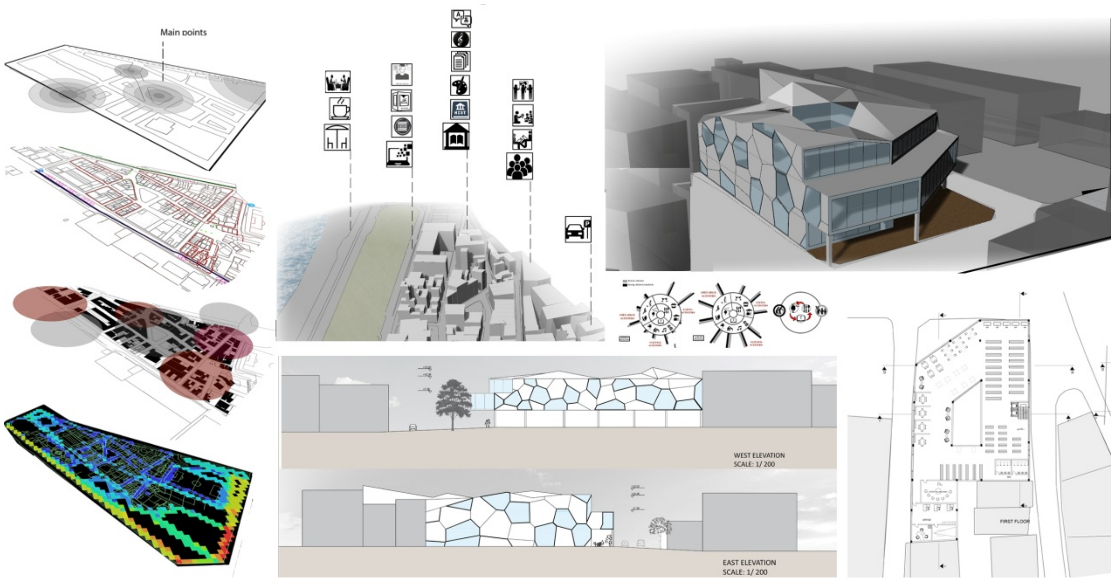

Figure 3. Public library study of a student

Discussion

It is possible to categorise the design process of 3 student projects as the 'site analyses' stage in which the region is examined, the 'early design process' stage in which sketches are made, the 'design process' stage in which 3D models are done and, plans, sections, elevations are drawn, and the ‘presentation’ stage in which renders and boards are prepared. During 14 weeks, students used some programs at different time periods (at different stages) and also used some programs simultaneously to produce projects.

From the students’ projects, it can be seen that different kinds of software are used at each stage including site analysis, early design process, design process and presentation. Therefore, during the transitions between these stages, transitions between various software programs were also experienced. In Case 1, for instance, Photoshop and AutoCad were used in the site analysis stage; SketchUp was used in the early design process; Revit was used in the design process stage; and Lumion was used in the presentation stage. In Case 2, the following programs were used as the project progressed: Photoshop and AutoCad in the site analysis stage; Rhino in the early design process stage; Grasshopper, Firefly and Arduino in the design process stage. In Case 3, the uses of the programs were: AutoCad, and DepthMapX in the site analysis stage; SketchUp in the early design process stage; Rhino and Grasshopper in the design process stage; Illustrator in the presentation stage (Table 4).

Additionally, in the 3 students' projects, it is clear that more than one type of software can be used simultaneously at each stage. Therefore, there are continuous transitions taking place between the software used in each stage. For example, in case 1 and case 2, transitions were made between Photoshop and AutoCad programs during the site analysis stage. In case 3, a transition occurred between AutoCad and SketchUp programs in the early design process. In Case 2, Rhino, Grasshopper, Firefly, and Arduino were used together in the design process stage (Table 4).

When we look at the 3 different studies, it can be seen that the programs used by the students in the stage of site analysis are very similar, which are Photoshop and AutoCad. Again, in the presentation stage, it can be seem that the Photoshop is used by all 3 students. However, the programs used in the early design process and design process stages vary between the 3 students (Table 4).

According to how students want to improve their projects, the program proposal brought by the instructor can slow down the process to some extent, if the student is unfamiliar with its use. However, this did not prevent the design process and solutions to the various problems were solved by working with the instructor.

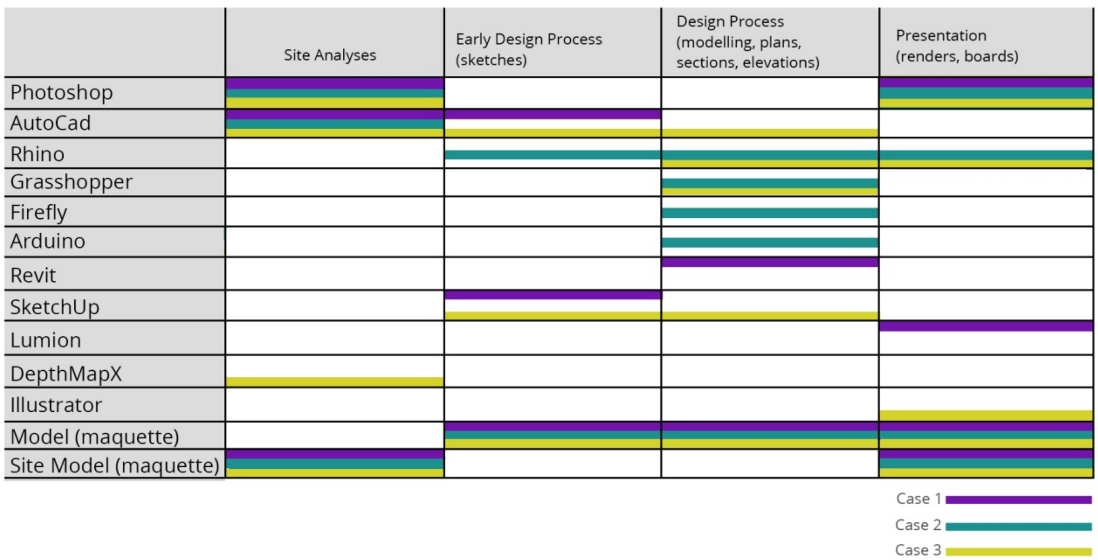

Table 4. Computer programs used by 3 students for different purposes throughout the design stages of the architectural design studio course

Conclusion

Although this study is specifically concerned with the use of computer-aided design tools within the architectural design studio, its inferences are related to all other design disciplines because, the use of computer technology is increasing rapidly in all areas of design. Since different computer-aided design programs serve different purposes, the use of multi-software concerns all areas of design. The studies, which will be carried out on the use of multi-software in design education, are thought to contribute to the development of those methodologies that will be followed by educators in universities. In addition, such studies are thought to be of interest to computer programmers in terms of interface design development and transition between programs.

In today's architectural design studio education, it is inevitable for students to use more than one program and to make transitions between the programs. The studio supervisor(s) should therefore be sufficiently knowledgeable about the many different types of programs, which are important for developing the student's project, so that they can pass on information about which programs the student should be directed to and how the transition between these programs might be.

However, according to the statistical evaluation of the questionnaire, it seems that if a student is interested in computer and technology this encourages their use of multi-software. In other words, as the student becomes interested in computers and technology, the difficulties of using multi software are more easily overcome, their use of the technology increases.

Some students may find the interface of some programs more complex than others, because the working principles behind them differ. For example, while the AutoCad program works the same way as drawing on paper, the Revit program works with object-based modelling, and the Grasshopper program works with coding principles. However, if a student is interested in computers and related technology, they may be encouraged toward the use programs of differing complexity with greater confidence, creativity and competence.

The use of computer programs by architecture students related to the purposes of their study makes them more enquiring in this area. Students, starting from an early stage of architectural education, can get into the habit of acquiring information regarding the best purposes for which different computer programs can be used (especially various plug-ins).

Seeing the purposes and diversity of the programs and knowing how to transition between them also helps the student to find the environment in which they are more comfortable, because, every student experiences the design process differently in terms of their varying knowledge and past experiences. As an example, some students prefer to start in a 2D environment for their designs, while others prefer to start in a 3D environment.

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Book Review

Drawing for Science, Invention and Discovery: even if you can't draw

Author: Carney, P. (2018).

Publisher: Leicestershire: Loughborough Design Press.

ISBN: [paperback] 978-909671-19-5 £9.99

eISBN: [mobi] 978-1-909671-20-1 £3.99

Reviewed by Alison Hardy, Nottingham Trent University, UK

For me, this is a timely book from Paul Carney. Two of my Master's students have recently investigated how, and if, they could help their pupils overcome their drawing anxiety. Carney's book would have been a useful source. There has been little research about drawing anxiety and developing drawing skills to improve the cognitive processes that lie behind creativity and innovation. My students, Emma and Jaye, have drawn on work by Lane, Seery and Gordon (2010), who researched how freehand sketching can be developed as a competency, and Nicholl's work that built on his and McLellan's (2007) investigation into creativity. But they have found little published work that exemplifies how to combine drawing and creativity. Carney's book goes someway to redressing this; the book aims to connect creativity, drawing and innovation through explanation, exposition and exercises about nine process, which Carney claims are the 'key cognitive processes that drive innovation, invention and discovery'. Carney's claim is that by recognising and understanding the cognitive process, along with undertaking exercises that develop these cognitive processes, drawing skills will improve and because drawing skills improve the reader will be a more creative engineer, scientist, mathematician or pioneer.

The current state of art and design education in England, and other countries, explains why this book is well-timed from a political and educational perspective. Carney is challenging ideas about the ways of thinking that cannot be taught through traditional academic subjects; art, design and other creative subjects are currently side-lined in the English curriculum (Hardy, 2017a; 2017b). Paul Carney has taught for over twenty years and is now an art education consultant with a website (www.paulcarneyarts.com) full of resources for art teachers and others interested in art education. Previously an advanced skills teacher in England and council member of NSEAD (National Society for Education in Art & Design), Carney is an art education consultant for different education sectors. This book is drawn from Carney's expertise and experience as an artist and teacher, and gives his book credence.

'Drawing for Science, Invention and Discovery' is a short (95 pages) and beautifully presented book, which is the norm for books from Loughborough Design Press. With eleven chapters, a forward by Professor Alice Roberts, and appendices, the book can be read in a few sittings, but if readers want to fully engage with the exercises then they need to set aside several days over a few weeks, otherwise they will not gain from the book's intention of improving their cognitive processes. The foreword includes one of Robert's drawings and she uses this to exemplify the connection she has between physics and art. It gives a nice insight into how someone at the top of their field uses skills from different disciplines.

Chapter one in a concise introduction to the book, setting out Carney's objective to 'identify the mechanisms from which the world's greatest inventions and discoveries come about and to demonstrate that these can be illustrated, explained and taught through drawing' (page 10). This objective is the structure for the nine central chapters, which focus on a different trait that Carney thinks are behind the world's greatest innovations: observation, collaboration, knowledge, serendipity, methodical alternative viewpoints, trial and error, and visualising.

The nine central chapters are laid out in a similar fashion, making it easy for readers and aspirational creators to dip into. There is no need to read each chapter in turn. Also, because each trait is explored in three distinct ways, through case studies, discussion and exercises, there is no compulsion to read the whole chapter. To find out how a trait was used by artists or scientists, read the case studies; the discussion will help readers understand how people can develop a trait; or to playfully experiment, then try an exercise. The case studies are short and exemplify the trait; for example, Percy Spencer's serendipitous invention of the microwave oven because of his sweet tooth or the collaboration between a diverse group of two hundred people to produce a new interpretation of the Magna Carta. These are just long enough to give a taste of how the trait is used to invent and create. When these are at their best Carney provides notes on the margin directing readers to websites. Some case studies would have benefited from more detail or a reference for further reading. However, Carney clearly has an extensive knowledge of a numerous scientists and artists, and inventions and discoveries, so he never repeats examples between chapters. The exercises are well presented with easy to follow instructions, this leads the reader to 'having a go'. Carney's relaxed writing style helps with this, step-by-step instructions are provided for some and many have visual examples. These pictures are clear and the examples informative – they suggest that the exercises are achievable even for the most novice artist. The resources in the appendices are invaluable and most photocopy well. As mentioned, the visual appearance of this book is appealing; the graphics are clear and its presentation is clean, unfussy and accessible.

The inherent strength of this book is Carney's knowledge and experience of art, creativity and innovation. The nine traits are deliberate chapters and there is a sense that Carney has come to settle on these traits though his own journey of discovery and creativity. His confident writing, which some may find informal, gives weight to his choice and organisation of the nine traits. However, it is his dependence on his own experience, interpretations and discovery that some may argue is a flaw of the book. Because the content is drawn from Carney's experiences and understanding, the book may be lacking in rigor for some readers because there is no evidence to support his claims. However, I do not hold that view. For me, this book is neither academic nor is it a textbook, instead it is a hybrid. Not based or driven by peer-reviewed research, but in experience and thoughtful reflection. Carney presents ideas and interpretations based on his reading and experience, supported by references and links to follow, with exercises he seems to have used when teaching and running professional development courses.

There was a fault line running through the book, from the front cover, through some chapters and onto the back over. I was confused about the target audience and purpose – who has Carney written this book for? Four reader audiences are mentioned in the book's blurb: scientists, mathematicians, engineers and pioneers; but some exercises refer to teachers and students. Is the book to be used by scientist who also teaches or lectures? Or is it for every one and anyone who wants to draw to discover, as the title suggests. I wondered if this was poor editing - Carney may be using exercises from his archive of resources designed for art teachers and their pupils and the exercises have not been reworked to fit the book's wider readership. The intention of the book was also confused by the title, the blurb and exercise which involved more than one person. The book's title suggests that readers will learn how to draw for science purposes, to invent and discover; however, the book's blurb talks more about understanding the cognitive processes and exercises. Then, some exercises need a teacher to manage the process or others to gain the fullest benefit. This is disappointing and, for me, this (minor) fault meant the book lost its direction at times.

As someone with some drawing skills and who understands that practice does improve drawing skills, I felt daunted by some exercises; so, others who are anxious about drawing and feel they cannot draw will probably feel this even more. For example, in chapter 8, Alternative Viewpoint, the exercises bought back my anxieties when I was asked to draw something from different perspectives; a valid exercise but intimidating. Yet, it is Carney's accessible writing, his belief in the traits and how they will improve anyone's creativity that will draw in an unconfident or inexperienced artist.

Overall though, this is a positive book, with energy and enjoyment emitting from the pages because of Carney's ideas and beliefs. He tells stories about familiar and unfamiliar scientists and artists to entice readers in, leading them gently to exercises that are, in the main, accessible. For those not interested in developing their creative skills but are interested in challenging the current dominance of knowledge-rich curricula in education it will be useful to read through the case studies, Carney presents arguments for the importance of drawing as an essential component of cognition. I will be recommending this book to Emma, Jaye and other students who are interested in understanding the cognitive processes that connect creativity, drawing and innovation.

References

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