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Endings and beginnings

Prof Kay Stables, Goldsmiths, University of London
Dr Lyndon Buck, Buckinghamshire New University

The publication of this final issue of the journal for 2019 comes at a very sad time for many of us involved in design education as it coincides with the death of Ken Baines, one of the pioneers of design education in schools and a lasting inspiration to many readers and contributors to this Journal and its predecessors. In this Issue's Reflection, Eddie Norman, Editor of the Journal from 2005-2015 pays tribute to Ken's massive contribution to design and technology education, along with a tribute from Niall Seery and Donal Canty whose research group built so much of its foundation on working with Ken and on his writing. For both those that did and didn't know Ken, these tributes combine to present understandings of who Ken was and how and why he has been such an inspiration for over fifty years. Adding a personal note, Ken was a particularly important person for Kay, having become a role-model, unofficial mentor and guiding light when she studied with him at the Royal College of Art in the Design Education Unit, beginning her formation as a design education researcher and enabling the development of her foundational thinking on the importance for humanity of design capability and its development through education. Very little that Kay has done as an educator, researcher and writer doesn't bear witness with this either implicitly through her philosophy and thinking or explicitly through extensive citation of Ken's own writings. He will be missed, but his contribution lives on through the impact he has and continues to have on others.

The foundational thinking on humans and design capability that Ken's work provided had strong elements of how we design, the processes at play, and the realisation of design's contribution to the world. In the research articles presented through this issue of the journal both the underpinnings of designing and new ways of developing young design and technologists are apparent. Through the articles there is a pedagogic thread, critiquing existing approaches and providing new pedagogic perspectives responding to shifts in thinking and advances in technology.

In **Design for the well-being of domestic animals: implementation of a three-stage user research,** Pınar Kaylan and Gülşen Töre Yargın (Middle East Technical University, Turkey) present a study of user-centred design where the users in question are domestic animals. The research aimed to explore student's perspectives on their learning and design experiences in this unique context where the focus was on the pets themselves – their well-being rather than that of their owners. One aspect of this was an intention to break away from more anthropocentric approaches to designing for animals. The project involved students work in teams of three to design a "product family" that aimed to improve the "emotional intelligence and well-being of dogs and cats". Students were encouraged to focus on daily routines, behavioural patterns and instinctive motivations. The 8-week project involved an introductory home visit, working with veterinary experts to lab test initial models and a final home visit to test final outcomes. The researchers took an interpretivist stance, gathering data from an interview with students sometime after the completion of the project. The article reports on the analysis of the interviews, highlighting the particular value of the stage where the students are working with experts and also the final home visit for testing their outcomes where the owners acted as interpreters for their pets. A particularly valuable contribution from the research is the extent to which students were challenged by being taken completely out of their prior experience, and the design learning that came from genuinely being placed in a situation riddled with uncertainty and wicked problems, where their preconceptions had to be re-considered and where the more their gained understanding and empathised with their users, the more they abandoned ideas that were based on anthropocentric considerations. A great example of this is given in the article where students reject an idea for designing a toilet for dogs who are left alone for long hours when they realise that the idea is beneficial for an owner, but not for a dog who needs regular walks. The research presented in the article provides both food for thought and inspiration for creating scenarios that genuinely disrupt thinking and confront students in ways that develops deep understanding of user-centred design.

Those particularly interested in this article may wish to read an article on designing for stray animals, published in Issue 24.1 of the Journal (February 2019), contributed by Yavuzcan, Şahin, Gür, Sevgül & Yavuz.

In A case study of game-based learning in interior design studios, Zina Alaswad (Texas State University, United States) presents research that provides fresh and detailed insights into design pedagogy enabled by game-based learning. She begins by presenting a critique of traditional design studios, identifying a misalignment between allotted studio time and workload expectations, an unhelpful master-apprentice model and unclear assessment approaches. She then moves to explore this further by using activity system theory to research a game-based learning approach as an alternative model. As an introduction, brief account of the theory of activity system theory is presented, followed by an outline of identified affordances of game-based learning. The two main questions explored how students perceived game-based learning as an approach to address the issues raised by her critique and how the students' perceptions confirmed the affordances identified. The research design presents the structure of the case study approach, the context in which the study was conducted and details of sampling, data collection and thematic data analysis. The research itself was small scale but highly detailed and, in itself, provides a valuable model for conducting in-depth, progressive, case study research. The thematic analysis provided insight into the two major areas being researched at a level that goes far beyond the surface level of the questions. For example, in exploring the ways in which game-based learning addresses workload distribution, we hear about the understandings that students gained about their own approaches to designing, the deep thinking that was afforded, their understandings of how the approach maintained the flow of their work, how they used their time, how they experienced creative freedom within a structure. The author recognises the limitations of the study, not least the small number of participants, but her claims are for the ways in which this study can contribute to pedagogical developments in design studios. Despite the small numbers, the richness of insight provided makes the article a fascinating and highly valuable contribution.

In **Constructivist Digital Design Studio with Extended Reality for Effective Design Pedagogy,** Zahid Islam (University of North Texas, United States) highlights challenges for design education pedagogy that arise from advances in technology along with Generation Z's ubiquitous use of electronic devices and a shift from the 'Information Age' to the 'Experience Age'. The research focuses on these challenges in the context of learner preferences and cognitive processes of learning when traditional approaches are compared to using Extended Reality (virtual, augmented and mixed) platforms. A very useful background is provided to the shifts from traditional studio pedagogy rooted in 18th and 19th Century 'French Rationalism, through 20th Century developments from the Bauhaus onwards to recent developments, including those linked to a shift from information to experience and the increased influence on pedagogies of new technologies. There has been much discussion in recent years about the effectiveness of pedagogies in respect of both cognitive load and learner preference and this study provides interesting evidence in relation to these in the context of design pedagogy. Taking a constructivist stance and applying a quantitative methodology, the author explored the correlation between learner preference and the mode of information delivery – tradition words and images compared with extended reality approaches. A rationale is presented that design students, mostly visual and kinaesthetic learners, prefer information delivery that has a high level of tactility and visual cues and that extended reality could support this in ways that decrease cognitive load whilst increasing motivation to learn. 32 interior design students from various levels of tertiary education were involved in a universal design project. The group were split in half – one receiving a traditional approach, the other the extended reality approach. Pre-testing via a Visual, Aural, Reading & Writing and Kinaesthetic (VARK) learning styles inventory and post-testing via a Technology Acceptance Model (TAM) survey provided data on learning preferences and on subjective perceptions of the use of technology for delivery information in design studios. Results included that the perceived ease of use and perceived usefulness of the extended reality delivery mode was significantly higher than a traditional approach and that the two delivery modes compared with learner preference showed higher levels of perceived usefulness for visual and kinaesthetic learners. The research opens up ideas for technology related pedagogic approaches in our changing world.

In **Examining Estonian school teachers' attitudes towards the use of applied scientific knowledge within craft education,** Gisli Thorsteinsson, (University of Iceland) **and** Andry Kikkull (Tallinn University, Estonia) explore possibilities for craft education can be supported by linking to knowledge that is being covered in science lessons. Their research took place in Estonia where, in 2014, the government introduced a new curriculum that emphasised integration and cross-curricular activities. The article provides a case for linking science and craft through focusing on applied science. It also provides a background to the history of craft education in Scandinavian countries, particularly emphasising the pedagogic aspects and historic linking of craft and science. Current craft subjects have a technological focus, alongside hands-on learning and creative thinking. The research involved interviews with craft teachers and observation of craft lessons through which they explored aspects such as whether teachers considered that their National Curriculum was helpful in integrating science knowledge in craft education, how aware teachers were of integrating science and craft, how applied knowledge was used in lessons and what teachers consider benefits of integration to be. The researchers present findings that suggest a common trend – that teachers support the theory of integration and can see how craft can play a significant role in helping learners engage with and understand scientific and mathematic knowledge, but that in practice there was little evidence of this happening. The exception to this was where a teacher already taught more than one subject. Various reasons are suggested for this, such as lack of guidance for integration science and craft provided in the national curriculum craft syllabus itself alongside a lack of support resources, a fear that craft could become a supplementary subject, supporting maths and science. The authors defend the value of integration, but, based on their research, provide a valuable list of conditions for success for introducing integration, presented in the conclusion to the article.

Baynes ARCA … Our Friend and Colleague, died on 5 October, 2019

Ken Baynes was born at Eynsford in Kent on 10th April 1934. He studied stained glass at Bideford School of Art in Devon and the Royal College of Art in London, where, in 1959, he became editor of the college magazine, *Ark*. While editing *Ark* his professional interest moved to the media, particularly magazines and exhibitions. On leaving the RCA he became assistant editor of the international graphics journal, *Graphis* based in Zurich. When he returned to London in 1963 he established his own practice as a writer, editor and designer.

Although trained as an artist/craftsman, Ken spent his professional life working as a researcher, designer, educator, writer and advocate of design education. He was one of the pioneers of design research and design education having worked with Peter Green at Hornsey College of Art in the late 1960s and with Professor Bruce Archer at the Royal College of Art where Ken headed the Design Education Unit in the 1970s. He became a Visiting Professor in the Department of Design and Technology at Loughborough University (now Loughborough Design School) in 2001. At the centre of his work were two main themes: the use of exhibitions as a medium for education and entertainment and the attempt to develop better strategies for teaching art and design in primary and secondary schools.

He pioneered the use of exhibitions as a medium both for research and popularisation having worked with the Welsh Arts Council, the National Portrait Gallery, the Science Museum, Glasgow Museums, Edinburgh City Council and galleries in Sweden, Denmark and the United States. For the Welsh Arts Council he developed a series of ground breaking exhibitions intended to relate art to the life experiences of 'ordinary' people. Many toured in England and Scotland after opening in Wales. They included *Snap!* (with the National Portrait Gallery), the Art and Society Series, *Scoop Scandal and Strife* (which toured in the Netherlands) and *The Art of the Engineer* (with Francis Pugh and the Science Museum).

He started working on exhibitions with his wife Krysia Brochocka with *The Art of Lego*, which was seen by 1.4 million people during its tour of the UK. Together, they specialized in exhibitions that appeal to children and family groups and which emphasize making and aesthetic awareness. The emergence of the approach taken by Brochocka Baynes began with *The Art Machine* (1990) for Glasgow's cultural capital celebrations. *The Art Machine* then toured to the Barbican Centre and Copenhagen. The fundamental concept was to first surround the visitor with inspiring exhibits from artists, craftspeople and designers, then to reveal the processes used to create them and finally to invite participation in a series of creative and imaginative activities reflecting the same qualities as the exhibits. Design activity was the focus of *Design Works* (1994) shown in Birmingham, Edinburgh, Newcastle, Croydon, Manchester, Leicester and at the Galway Children's Festival. Visitors engaged in design games at their own level using specially developed modelling media. Other exhibitions included *How to be Bottom* (Barbican, 1995), *Animal Magic* (Edinburgh 1997, then shown in York, Cardiff and Leicester), *Weaving Stories* (Edinburgh 2003, then shown in Gateshead, The Harley Gallery, Croydon, Paisley and Motherwell) , *Artworks* (Edinburgh1998, then Croydon), *Seeing Dragons in the Clouds* (The Harley Gallery 2006, then shown in Gateshead, Edinburgh, Sleaford, Croydon, Wick, Wolverhampton and Stroud) and *Quick on the Draw (*2008) which explored the everyday uses of drawing through a series of case studies, and a studio of activities for all ages. This exhibition was shown in Edinburgh, The Harley Gallery and Croydon, and ended its tour at Loughborough University. Brochocka Baynes' last exhibition was *Cloud Nylon* (The Harley Gallery, 2011, then Ruthin, Shipley, Rochdale, Stroud, Bilsden, Worcestershire and Walford Mills).

Turning to Ken's work as an advocate for design and design education, he was a broadcaster, advisor, author, editor, campaigner and researcher. He was the scriptwriter and presenter for the *Design Matters* television series produced by Malachite for Channel 4 where he was involved in creating 22 programmes dealing with every aspect of design. He contributed regularly to *Design* magazine, the *Times Literary Supplement* and *Architectural Review*. He was the co-founder of the Design Dimension Educational Trust and Editor of *Cook School*, a magazine for teachers published by the Focus on Food Campaign. He was on the Advisory Board of design education bodies in Illinois and New York. With Krysia he was joint editor of the Nelson Design and Technology resource and a member of the education committee of the Design Museum. He wrote reports and conducted research for the King's Fund and with Krysia for the Ove Arup Foundation, The Design Council, Scottish Natural Heritage, the Crafts Council and Loughborough University. He campaigned for 'practical' education in a number of related fields including food and cooking, drawing, and gardening.

His earlier books included *Industrial Design and the Community* (1968), *Attitudes in Design Education* (1968), *Art in Society* (1975, which was translated into French, Spanish, Italian, Dutch and Turkish and also published in the United States), *About Design* (1976), *The Art of the Engineer* (1981, with Francis Pugh) and *Gordon Russell* (1987).

I got to know Ken Baynes following his appointment as a Visiting Professor at Loughborough University. Together with Professor Phil Roberts who had been appointed as Head of the Department of Design and Technology he established the influential Orange Series of publications concerning design education research. In 1992 he co-authored *The Nature of Research into Design and Technology Education* and *Modelling: The Language of Designing* with Phil Roberts and Bruce Archer. One focus of Ken's research in the 1990s was developing greater understanding of the behaviour of very young, pre-school children when designing and he published three Orange Series publications associated with this work: *Children Designing* (1992), *Designerly Play* (1994) and *How Children Choose: Children's encounters with design* (1996). Of course I read all these publications with great interest, but I first worked with Ken as co-editors with Georgina Royle of *New Designer* magazine in 1996-97; a magazine written for secondary school students.

Ken's continuing research interest focused on modelling and the insights offered to the arts and design by new developments in cognitive science and digital media. I worked closely with Ken on the preparations for his modelling seminar series (2009-2010): *Modelling and*

Intelligence; *Modelling and Design*; *Modelling and the Industrial Revolution* and *Modelling and Society* which were also published in the Orange Series. These culminated in Ken's seminal book *Design, Models of Change: The impact of designerly thinking on people's lives and the environment*, which was published in 2013.

In 2012, Ken and I established Loughborough Design Press (LDP) partly because of the difficulties we had in finding a publisher for Ken's book, but also because we felt there was a need for an additional publication route for design education researchers. Our motivation could perhaps be best expressed by the quotation that Ken chose for his page on LDP's website:

> "The biggest challenge facing us is to create a sustainable future. Designerly thinking will play a key role. We'd better be good at it. The survival of homo sapiens is at stake." (Ken Baynes)

I had the great pleasure of editing two further books with Ken. *Design Education: a vision for the future* (2013) which was based on the John Eggleston Memorial Lecture Ken gave in 2010 at the Design and Technology Association's Annual Conference and *Design Epistemology and Curriculum Planning* (2017) in which Ken showed the breadth of his thinking through contributing a chapter entitled 'Design epistemology: a wider perspective' and, memorably, a chapter of cartoons exploring the making of meaning without words. Throughout the establishment of LDP from selecting fonts to book editing and design, Ken's extraordinary knowledge of the design field, education and publishing within it was apparent. Ken certainly did everything he could to provide the opportunities for humans to develop and understand designerly thinking. In one of our last conversations he said that he thought "he might have gone on too long", but I think we would all have liked him to go on for much longer. He was an important and influential thinker in the world of design education. He was a great communicator and his work challenged and inspired many people in the UK and beyond. His passing is a great loss to us all.

Eddie Norman
Emeritus Professor of Design Education, Loughborough University

A tribute to Ken Baynes from the Technology Education Research Group

It is with heavy hearts and much appreciation that we have this opportunity to pay our respects to Prof. Ken Baynes RIP. Hearing of Ken's passing represented a real loss to everyone involved in design education and it was received here with great sadness. Ken was a great friend of our research group, who was always so agreeable to support our research endeavours through offering us his expertise in a manner that was always encouraging and selfless in order to help us to develop and grow. On hearing the news, we began to recount Ken's impact on our thinking and research. Our discussions meandered from playful design, to models of change, to visionary, captivating orator, gentleman – fittingly and analogous to his framing of the importance of graphicacy and modelling, it is difficult to fully capture his impact on us through natural language.

Our first meeting with Ken was both timely and profound. We had just converged on 'design' as the kernel of our research agenda and little did we know at the time, that many years later we would still be unpacking his many thoughts and contributions on human capacity. We are privileged to have worked with Ken and extremely appreciative of the time that he spent engaging with TERG. His guidance and sincere kindness towards our research endeavours and students has had a significant impact on all of whom he engaged with.

Ken has had an immeasurable impact on the thinking of TERG and his impact lives on through current PhD research. For example, standing on the shoulders of giants perfectly captures the impact of Ken's work on Joe Phelan's PhD research and we are confident that he will pay tribute to Ken – As he could not have picked a better Giant!

Through Ken's outstanding contributions to the field of design education – his incredible intellect and vision will forever live on.

We would finally like to offer our sincere sympathies to Ken's family and friends,

Dr. Niall Seery
Co-Director of the Technology Education Research Group
Vice President Academic Affairs and Registrar, Athlone Institute of Technology
Dr. Donal Canty
Co-Director of the Technology Education Research Group
School of Education, University of Limerick

On behalf of the Technology Education Research Group, Ireland

Design for the well-being of domestic animals: implementation of a three-stage user research model

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Gülşen Töre Yargın, Middle East Technical University, Turkey

Abstract

This paper presents how we, as design educators, integrated user-centeredness into a design studio course project that is concerned with improving well-being of domestic cats and dogs. Since the primary users of the project were identified as domestic animals, we carried out the project in collaboration with experts from a veterinary medicine school who study animal behavior. We developed a three-stage user research model to enable students to familiarize themselves with the physical and emotional needs of the animals at the beginning, and test their prototypes with the users in both the lab and home contexts during the project. The empirical basis of the paper comes from the interviews we conducted with 12 students who participated in the project, in order to explore their experiences of designing for animals. The paper shows that including animals in a design process as participants, through iterative trials in the real use context, serves as a good strategy to not only overcome the challenges of designing for animals, but also teach students the importance of user-centeredness and building empathy in design in a broader sense.

Keywords

Well-being, design for animals, user research, user test, collaboration, design education, animal-computer interaction

Introduction

Over the years, there has been a transformation in the scope and definition of design activity. With integration and pervasiveness of technology in products and services, the focus has been shifted from object to user and experience as the major subjects for design (Giacomin, 2014; Hassenzahl & Tractinsky, 2006; Redström, 2006; van der Bijl-Brouwer & Dorst, 2017). This shift has also impacts on higher education in design as well as primary and secondary education. At undergraduate level design education, there have been efforts to integrate topics, such as human factors, ergonomics and user research (e.g. Bødker & Klokmose, 2012; Hanington, 2010; Vorvoreanu, Gray, Parsons & Rasche, 2017; Woodcock & Flyte, 1997). At lower grades, in a similar way, importance of considering users' needs, wishes and values in the design process is highlighted through design and technology courses in the curriculum (DfE, 2015; Nicholl et al., 2013; Klapwijk & Van Doorn, 2015).

Within the later stages of this user-centered shift, especially in the last two decades, the attention has been transferred from usability and pragmatic qualities of user-product interaction to more hedonic aspects such as pleasure and joy (Blythe & Monk, 2018), and eventually to improving quality of life and well-being (Calvo & Peters, 2014; Desmet & Pohlmeyer, 2013; Hassenzahl, 2018). According to the World Design Organization (2018), improving well-being is also considered as one of the major goals for industrial design among the Sustainable Development Goals identified by United Nations. Accordingly, there are many examples of design for human well-being. Focusing on animal well-being, however, is a fairly new issue within both design practice and education (Mancini, Lawson & Juhlin, 2017; Hirskyj-Douglas, Pons, Read & Jaen, 2018). The study of animals and animal behavior for developing products dates from much earlier with examples of technologies and products designed for animal use in different fields such as agricultural engineering, cognitive psychology and animal behavior (Mancini et al., 2017). Studies in these fields have generally focused on the outcome of an animal's interaction with technologies and products, for example, with the aim of increasing animal productivity or investigating animal cognitive structures in order to make inferences about human cognition. In that sense, they serve for the benefit of humans rather than having animals at the center and improving their life quality and well-being.

Animal Computer Interaction (ACI), as an emerging area, aims to support the development of interactive technologies by focusing on animal well-being through accommodating their physiological and psychological needs. With this agenda, it is established as a field that criticizes the aforementioned anthropocentric view in design for animals (Mancini, 2011). In ACI, various tools have been developed to provide playful interactions with animals and humans, monitor their health and behavior, and support animals that work with or for humans in tasks such as caring or rescuing (Hirskyj-Douglas et al., 2018). Since, in these cases, the human is still considered as a critical stakeholder in the interaction, validity and possibility of animal-centeredness and consideration of animals' actual needs are questioned for the area of ACI (Mancini et al., 2017). Likewise, animals' inability to express their needs and expectations may hinder taking their real needs into account, thereby causing power inequality between the designer and the animal in the design process (Lawson, Kirman & Linehan, 2016). Therefore, having a participatory design process in which the animal is considered as a genuine stakeholder remains questionable.

In 2017-18 fall semester, we, two design educators, decided to devise a design studio course project that focuses on design for animals with third year industrial design students. From design education perspective, we saw potential for raising design students' awareness of user-centeredness through designing for animals by enabling them to experience collaboration with domain-specific experts. Our discussions with an academic veterinarian, who later contributed to the project as an expert, also encouraged us to explore these potentials to improve the well-being of domestic cats and dogs. Being an expert in animal behavior, she explained to us how the existing products do not fully satisfy the emotional and physical needs of cats and dogs, except few expensive products that cannot be afforded by many owners (see for example enrichment toys such as Kong Classic, other interactive toys and exercise equipment for pets produced by firms such as Nina Ottosson, and technology integrated products such as FitBark, Whistle, CleverPet). With her support, we formulated the underlying question of our design brief as follows: How can we design for cats and dogs with the aim of improving their well-being, by placing them at the center of the design project? By doing this, we wanted our students to explore and care for the 'needs and expectations' of a user group from whom they have very different emotional and bodily experiences.

In this paper, we present how we integrated user-centeredness into this animal well-being project. To achieve this, we draw on both our formulation of the project, and the interviews we conducted with our students to understand their interpretation of the experience of designing for animals. In the following sections, first, we outline the structure of the course by explaining the objectives of each stage. Then, we present our methodological approach by explaining the interviewing and data analysis processes. Later on, we report students' overall perceptions about the project and the three user research stages. Finally, we discuss our findings by underlining their implications for design education and practice.

The design project: product family for improving well-being of cats and dogs

Our university-based, industrial design studio activities have been shaped by our concern of providing our design students with real life encounters with diverse partners from various professional and educational organizations, i.e. manufacturing companies and non-profit organizations (Börekçi, Kaygan & Hasdoğan, 2016; Börekçi & Korkut, 2017; Kaygan, Demir, Korkut & Boncukçu, 2017). In these projects, we collaborate with experts whose professional experiences support us in achieving the learning objectives of the courses. This project was carried out at Middle East Technical University, Department of Industrial Design in collaboration with Ankara University Faculty of Veterinary Medicine, Department of Physiology, Behavior Clinic, during the 2017-2018 fall semester, as part of the third-year industrial design studio course. At the planning stage of the project, the expert from Ankara University explained the problems regarding existing products in the market: there is a limited number of products available that are developed for improving well-being of cats and dogs. Yet, since these products are (1) found expensive by owners, and (2) have limited life cycles as they cannot be upgraded or customized according to the changing needs of the animals, this creates a demand for low-cost sustainable solutions which can be easily afforded by owners. Addressing these problems, in this project, we asked our students to design a product family for improving emotional intelligence and well-being of cats and dogs, considering animals' daily routines, physical needs and behavioral patterns, as well as their emotional and instinctive motivations. The product family involved three products for different activities such as feeding, exercise and playing.

Table 1 summarizes the stages and activities we planned for the project. As design educators, this was the first time we planned a design studio project that takes non-humans as its users. In every studio project, we ask students to interview and, if possible, also observe the user group to understand their experiences, perspectives and needs. In this project, since students would design for a user group that cannot provide verbal feedback, we placed further emphasis on observing the user. We developed a three-stage user research model, which consists of (1) explorative home visits, (2) lab trials with experts, and (3) home trials. Table 1 shows where these stages are located within the project schedule.

Table 1: Project schedule and weekly activities

Project stages	**Weeks #**	**Activities**
Insight Generation	1	Literature search on existing products, animal behavior, caring and training
		Seminar on animal behavior
		User research task 1: Explorative home visits
Idea Generation	2	Identifying design directions
		Idea generation workshop
Detailing & Evaluation	3-4	Low-fidelity prototyping of preliminary ideas
		User research task 2: Laboratory trials with experts
	5	Preliminary evaluation
	6	*User research task 3:* Home trials and owner feedback
	7	Detailing and final screening
	8	Final evaluation

The project was carried out with 24 students (20 women and four men) in eight teams and lasted for eight weeks. Teams started the project by carrying out internet research on existing products, Do-It-Yourself solutions and games for cats and dogs, as well as typical behavioral attributes and physical actions, caring and training of cats and dogs. Following this, they carried out the first user research stage and then decided whether they would like to design for cats or dogs.

As demonstrated in the above table, there were three user research tasks. First, in the *explorative home visits*, students visited owners’ homes to observe the context of use, and to understand animal needs from the perspective of owners by interviewing them. In this first user research stage, students explored animals’ environment, products used by them, their daily routines, stuff and places they like or dislike, and activities they do when owners are not home. We provided students with the following directives to follow during the observations:

> The aim of this visit is to understand the daily routines of cats/dogs by interviewing the owner and to identify the products that are used by/for the pet in their original context. Ask the owner to show you all relevant items. These items can range from the products that belong to the pet, such as toys, food and water bowls, collar, other accessories, cleaning and hygiene products, to the ones that belong to the owner but are shared with the pet, such as a piece of furniture, a blanket, etc. In addition to these items, you can also ask the pet’s favorite places within the domestic environment.

In addition to this, we also prepared an interview schedule to guide students during their interviews with the owners. The schedule included the questions below:

- Can you please describe a typical day of your dog/cat starting from the morning when s/he wakes up? What kinds of activities does s/he do daily?
- What kinds of products does s/he use during these activities? Can we see them?
- Does s/he have a favorite item (among the ones you show or the ones that does not belong to him/her)? How does s/he use (or play with) it?
- What kind of things/objects does she like?
- Where is his/her favorite space at home? Why do you think s/he likes there?
- How does s/he spend his/her time when you are away from home?

Teams reported their research outcomes on posters, as illustrated below by Figure 1.

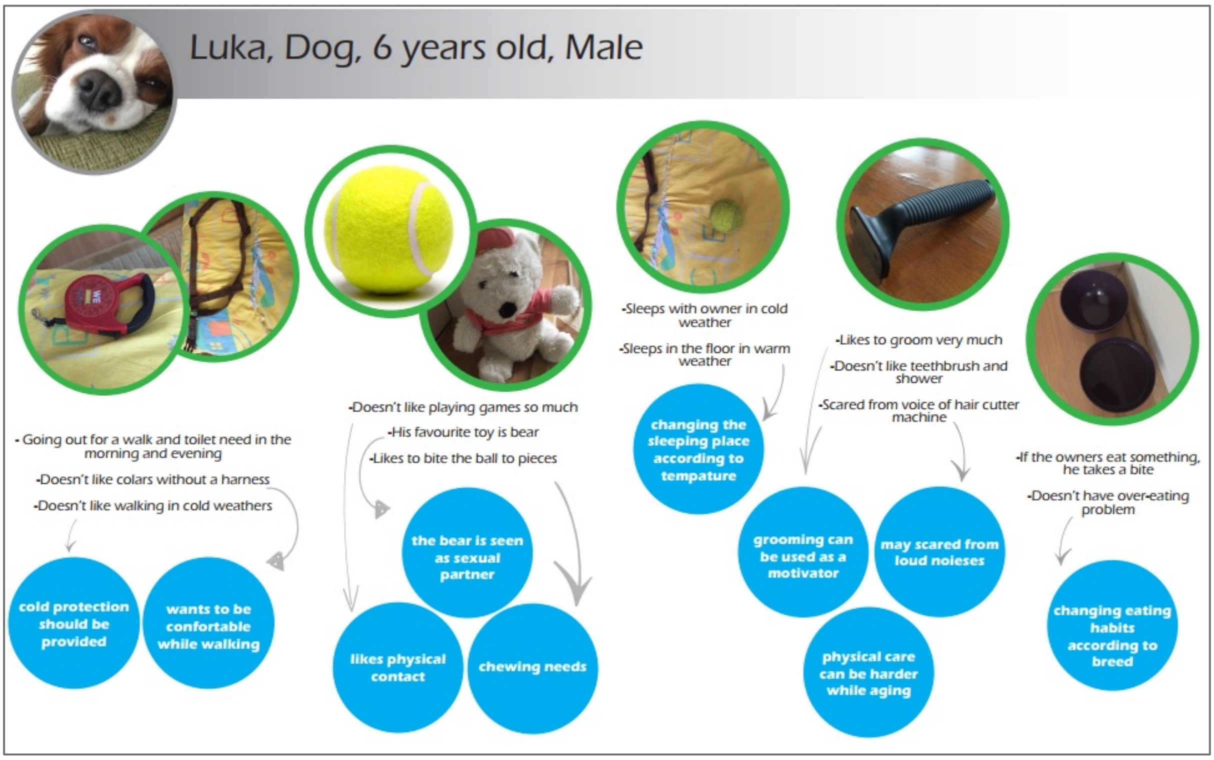

Figure 1. Findings derived from a dog's home visit by Koray Canlar, Melek İnür and Seren Sandıkçı.

In the third week of the project, students prepared low-fidelity prototypes of their preliminary design ideas for the second user research stage, which is *laboratory trials with experts*. The prototypes were tested by cats and dogs at Ankara University Faculty of Veterinary Medicine, Department of Physiology under the supervision of two academics in Behavior Clinic Laboratory. Before the laboratory visit, we asked teams to build the *working* mock-ups of all members of their product families, whenever possible, using actual materials that they plan to use or use similar materials that can simulate the qualities of the actual materials. Each team had 20 minutes to test their prototypes with the cat/dog invited by the experts, and receive feedback from the experts on their product family (Figures 2 and 3).

Figure 2. Gofret is trying to reach the food in the feeder

Figure 3. Gofret is playing with the toy

During these laboratory trials, we, as design educators, were present merely as observers, being careful not to distract the animals, for whom concentrating on the products was already difficult. Trial sessions were video-recorded by ourselves, so that students could watch them again and again later to improve their products. After the sessions, students were asked to organize their notes taken during the trials by considering the positive and negative aspects of their designs, and to propose areas for improvement.

In the sixth and seventh weeks of the project, following the preliminary jury after when students start design detailing, teams carried out *home trials* with their high-fidelity prototypes. In this third user research stage, students visited homes to try and test their projects with animals in their real contexts, where they feel comfortable, and concurrently received feedback from owners by observing the animals together (Figure 4). We advised students to shoot as many photos and videos as possible to be able to show the interaction of the animals with their designs, since it was not possible to bring cats and dogs to the final evaluation jury. After the home visits, we again asked students to consider positive and negative aspects of their designs and areas for improvement in light of the feedback they received on their improved prototypes.

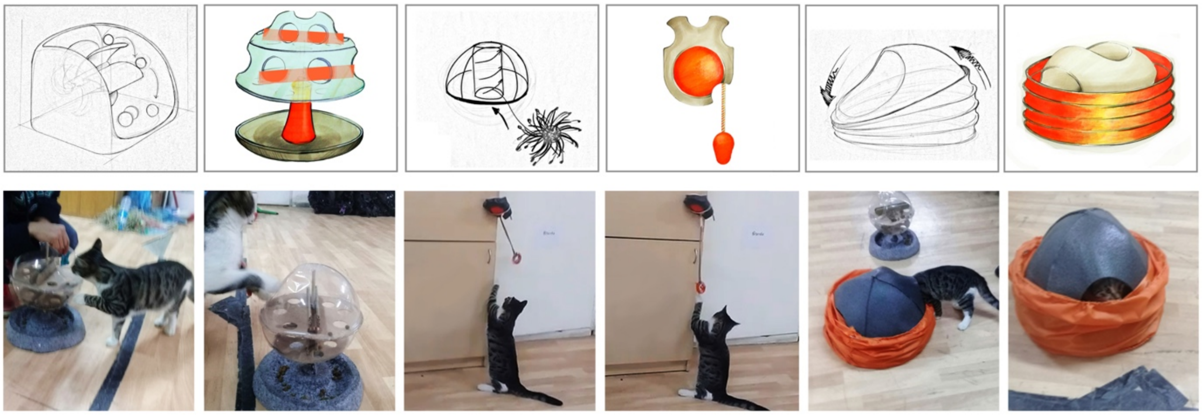

Figure 4. Photographs from home trials and sketches of the evaluated concepts by Dilara Erdoğan, Nihan Öztürk, İrem Yörükoğlu

At the end of the eighth week, the project was finalized with a final jury. Starting from the beginning of the project, we emphasized that this project focused on the well-being of animals and the target group was animals themselves rather than their owners. Throughout the project, we kept reminding students the centrality of the animals. Figure 5 demonstrates the final presentation board of a team, which designed for guide dogs for visually impaired people by particularly focusing on the tiresome and busy lives of guide dogs.

Figure 5. Dux product family for guide dogs

Research design

Since this research aims to explore students' perspectives on their learning and design experiences, our epistemological stance was interpretivist. Adopting an interpretivist stance requires researchers to gain a deep understanding of how participants make sense of their experiences within the given social context. To this end, we carried out semi-structured interviews with 12 out of 24 students (10 women and two men) who volunteered to take part in our research. In the selection of the participants we paid attention to include at least one student who have demonstrated full participation during the semester from each team, and to ensure the representation of both women and men students. We invited students to interviews via e-mail, explaining the aim of the research and how they will contribute by talking to us. The interviews were conducted almost a year after the project ended, in November and December 2018.

Before the interviews, we prepared an interview schedule, which covered questions regarding (1) the evaluation of the overall design process and each single stage of the project, (2) how and to what extent designing for animals is different from designing for human beings, (3) the skills and knowledge gained in the project, (4) how the focus on well-being was perceived by the student, (5) what would the student do differently, if s/he did the project again, and (6) the student's recommendations for us to improve the project. Interviews lasted between 20 to 40 minutes. All interviews were audio-recorded and were fully transcribed to be coded line-by-line.

As typical in interpretivist tradition, our aim was not to generate findings that can be generalized to the entire population. Instead, through in-depth data collection and analysis, our goal was to make conceptual inferences about designing for a non-human user group in order to trigger a new theoretical discussion on user-centered design, in both education and practice (Kvale & Brinkmann, 2009). Aligned with our research perspective, we carried out thematic analysis. In the first round of the analysis, two authors of this paper read the transcriptions and came up with themes separately. Then we explained the themes to each other and developed an outline. Doing this, we aimed to conduct 'analyst triangulation' to avoid individual priorities and biases (Patton 2002, p. 556). In the second round one author carried out a more detailed line-by-line coding following the outline, carrying the codes and related quotes to a spreadsheet in MS Excel to identify the most relevant and frequent themes. In order to illustrate and provide evidence for the findings, excerpts from interviews were selected and added into the analysis section, after being translated into English.

Analysis of the interviews

The project was identified as "challenging" by all participants due to the involvement of non-human users on three grounds. First, particularly for the students who did not live with cats and dogs before, it was very difficult to understand the needs, expectations and feelings of the user group in the absence of verbal communication. They identified animals, particularly cats, as unpredictable. Some students explained that they selected dogs as their user assuming that they will be more predictable and easier to communicate compared to cats. Since interviewing has been the most common and practical method for the students to get to know the user in their previous design projects, being unable to talk to the animals was their main concern at the initial stages of the project. Second, students stated that they find it challenging to design for a different body, with different capabilities, postures and ways of interacting with a product, of which they have no personal experiences to reflect on. In explaining this, some students said that although verbal communication with the user would be missing when designing for babies and small children as well, at least they share the same anatomy with them. However, for them, animals' actions, body movements and the ways in which they interact with products were completely illegible. Third, almost all participants indicated that the limited number of products available in the market for domestic animals, and the lack of available literature on their needs and development prevented them from carrying out an in-depth background research on this user category.

All students highlighted that the role of intense user research helped them to overcome these challenges throughout the project. Since there was almost a year between the end of the project and the time of the interviews, we asked what participants remember regarding the project, and then reminded the project stages to ensure a full account of their reflections on all three user research stages. Overall, the first stage, explorative home visits, was described as a “conventional” initial user research assignment that aims to get students familiar with the user, the use context and the most common issues and concern that users can identify regarding the project topic. In the interviews, students did not place much emphasis on the significance of the first stage, stating that all studio projects begin with this stage and they consider it a standard practice. In a couple of sentences, for example, a student explains below how her team benefited from the explorative home visits, where they interviewed the owners and made observations on the products used by their cats and dogs:

> I’ve never had a cat in my life. I didn't have much information about them either. However, we went to different people's homes and observed their cats, more than once. So, how does she [the cat] interact with a product? What does she need?

The other two stages, which are the laboratory trials with experts at Ankara University and home trials that teams have carried out after the preliminary jury, on the other hand, were underlined many times in the interviews. In response to our various questions on the most critical stage of the project, the most pleasurable stage of the project, and how students overcame these challenges, these two user research stages were mentioned as key by the participants.

In the laboratory trials, two experts brought a cat and three dogs to test the prototypes of the teams. In the selection of the dogs they took into consideration the different types of dogs addressed in the projects, puppies, very active dogs, and guide dogs, to make the tests as realistic as possible. Overall, for the teams who design for dogs, the interaction with the animal worked very well and they received good feedback. However, Kofi, the cat did not want to interact with the students and the products, and preferred to stay in her box. For these teams the laboratory trial remained merely an opportunity to get feedback from the experts. The teams who could observe the animals testing their products indicated that it was a very critical stage in their project, which shaped their design decisions considerably. One student, for instance, describes her experience as follows:

> Recently, I watched [the laboratory trials’ video] again. At the beginning, the things we foresaw were very different. We understood that we didn’t have full knowledge of their basic and instinctive movements. For example, we had this pedal idea. The idea was that when you push the pedal, food would drop. We saw that the dog never makes a movement like this. Well, for example, that thing was very good: the way the human thinks certainly doesn’t work the same way with the dog [how he thinks]. He never does what you foresee. […] So, trials are absolutely very important. In the projects for humans, we can somehow try on our own or with

> friends, we can experience them somehow, but we realized that animals are a completely different world.

Participant from another team also said:

> In my opinion, [the most critical stage] is trials in the veterinary clinic, because many of the prototypes we made were not actually interacting with the dog. The dog didn't understand [how our product works]. We saw what we did wrong there. It was something that happened to most of [our friends'] prototypes. Dogs... either it didn't happen as we planned or they never interacted. It happened to us as well. Bad dog went there and slept on it [the prototype] (laughs). In that respect, [the laboratory trial] was helpful in guiding the project.

Teams that design for dogs all shared similar opinions regarding the usefulness of the laboratory trials, where they received the first feedback from the user on their products. Participants whose teams designed for cats still argued for the significance of these trials, underlining the value of the feedback of the experts.

> Actually, since our animal was a cat, she was being shy, hiding, not approaching close enough to our projects, but again the veterinary experts were very helpful. Again, they provided feedback from cats' perspective or based on their own pet's behavior.

Overall, students defined this first encounter of their designs with the users and the experts as highly illuminating, providing them with significant feedback that guides their next design decisions.

Our analysis reveals that during the third user research stage, when teams made home visits to test their high-fidelity prototypes, students developed an emotional involvement with the project, carrying what they do beyond mere user test. They often used words such as "pleasure, happiness, enjoyment, fun" to describe their feelings during the home trials. In the data, we identified two factors that shape their deeper involvement. First, being in the real use context, animals were comfortable and acted naturally. Moreover, since students organized these visits out of the course hours, they could observe the animals for a longer time. Students believe that the feedback they received from animals, particularly from cats, was deeper, more genuine and reliable in the home context.

Second, the participation of the owners in the observation sessions is a strength of home trials. Since owners know the animals very well, they play the role of an interpreter during the observation sessions. They explain, for instance, why animals interact or do not prefer to interact with the students' designs in certain ways. The below quote illustrates this:

> The fact that the owners were being there, observing and commenting [on their pet's behavior] was very, very enlightening. For example, in your mind, you expect the dog to react in a certain way, but there is someone who knows him very well present there, there is his owner. [The owner] immediately explains his pet's behavior to you, like, "He does so, because he doesn't like this" kind of… For that reason, when you interpret [the owner's explanations] together with the

> movements the dog does, at least you can understand the reasons. This can be much clear and valid. Otherwise, there would be many things that you can't understand, like, "Why he [the dog] does that?" etcetera. Therefore, the presence of the owner as a factor is highly important.

Home trials, where animals feel more comfortable and owners play the role of the interpreter, seem to be where students can see their users as living beings with individual characteristics, tastes, preferences and habits. As students develop such a close and deep understanding of their users, they can better empathize with them, and get emotionally engaged with the project. This leads to satisfaction, which is a common emotion mentioned by participants. Observing the user interacting with the product in the ways foreseen by themselves, students get satisfied by both finally being able to understand the user, and contributing to their well-being through the products they designed. One student's account illustrates this very well:

> It was really enjoyable, because our prototypes were exactly of high quality. You know, they were good. We let the dog to try them. He directly picked the toy and started playing with it. That was a very nice pleasure, of course. As I said, to address a completely special group [guide dogs for visually impaired people] ... In such cases, you can't help it, you get a bit emotional as well. In the end, from our side, there is this satisfaction of designing a product for a being who is helping a visually impaired individual by making life easier. Also, I enjoyed it a lot when I explicitly saw this happened in reality.

Reflecting on these experiences, all students underlined the significance of iterative observation in a design process. While home trials were a stage that we placed into the project, once the students saw how they provided valuable feedback that can guide their design decisions, they made revisions in their models and made subsequent home visits. Overall, students saw the solution for designing for a user group with whom they are completely unfamiliar in iterative and close user observation. However, in the interviews they underlined that regardless of to what extent the designer can empathize with the user, iterative and, if possible, longitudinal user observation should be a standard practice in every design project. Some students indicated that after this project their perspective on user research has changed in general, and in their later projects they benefited from this perspective change. They all mentioned that at the end of this project they observed significant development in their observation skills.

Since the focus of the project was on the well-being of the animals, owners, who make the purchase decision and who place the product in their home, were considered as the secondary user. Designing for animals by caring primarily for their needs, expectations and emotions, students tried to go beyond meeting their basic needs and to improve their conditions. In some teams, we witnessed discussions on whether some design decisions prioritize the comfort of the animal or the owner. For example, a team initially suggested to design a toilet for the dogs' home alone all day for long hours. Considering that this may lead the owner to take the dog out for a walk less often relying on the product, they gave up on the idea. We observed that as students gained more empathy with the animals, they better prioritized their needs and emotions over the expectations of the owners.

Discussion

In the project presented in this article, we developed a three-stage user research model, which includes explorative home visits, laboratory trials with experts and home trials with owner feedback as described above. Drawing on our findings, we can suggest that this model worked well in terms of dealing with the challenges related to designing for animals indicated by our students at the beginning of the project. According to the students, the first user research stage enabled them to get familiar with the user and the use context, especially for the students who did not live together with cats or dogs before. At the second stage, where students visited Ankara University to carry out laboratory trials in the presence of the experts, students brought their low-fidelity prototypes to the users for the first time, and had a unique experience of observing animals interacting with the products. At this stage, the feedback of the experts who observed the animals with the prototypes helped them understand why animals reacted in a specific way, and how and in what ways the students could enhance the interaction of the product with the animal.

Students, however, placed more emphasis on the third user research stage, where they made home visits to test their high-fidelity prototypes with animals. They identified the solution for designing for a user group with whom they are completely unfamiliar and have limited communication as carrying out iterative and close user observation in the real use context. In line with Westerlaken and Gualeni's (2016) suggestion, our findings regarding this stage show that including animals in the design process as participants through iterative tests of prototypes and close observation of animal behavior serve as a good strategy to overcome the challenges of designing for animals. Similar to experts' support in the laboratory trials, owners' support in home trials was underlined by the students. As discussed previously, it is difficult to talk about a complete participation of the animal in the design process, considering the obvious communication barriers. However, our findings show that the presence of the experts and the owners in the role of enablers, facilitators and interpreters could increase the participation of the animals in the user trials by translating and explaining animals' responses and reactions to the designer.

In light of these findings, our research has three impacts on design education. First, we observed that designing for animals raised awareness towards the importance of user-centeredness in design. During the design process, to imagine how the product is used and perceived by the user, designers need to build their presumptions about users' expectations and needs into user models (Hasdoğan, 1996; Norman, 2013). Such models can be based on designers' personal experiences and professional expertise as well as information collected from potential users. When constructing user models, designers' experiential knowledge is effective on how they interpret user research findings (Oygür, 2018). As for novice designers and designs students, such models can be entirely built based on their previous experiences as a user. In the current case, since students do not have any shared experiences and capabilities with the user to build a user model on, it was difficult for them to foresee how their product could be used and perceived in the real life context. Therefore, without having any experiential knowledge of their own, they frequently felt the need to observe the user and consult an expert or the owner. This enabled them to experience and realize the benefits of user research in a design process and raised their awareness towards user-centeredness in identifying and verifying design requirements. This educational gain is also crucial for design and technology education in schools where teaching user-centeredness is one of the key goals (DfE, 2015). Besides, designing for animals can have additional benefits for pupils considering that interacting with animals has positive effects on children’s development (Endenburg & van Lith, 2011).

Second, students experienced empathic understanding with such a distant user group. Building empathy with users by leaving designer’s role and ‘stepping into the user’s shoes’ is considered as the key aspect of user-centered design (Kouprie & Visser, 2009; McDonagh & Thomas, 2010; Postma, Zwartkruis-Pelgrim & Daemen, 2012). Our findings show that especially close observation in the home context gradually enabled empathy with animals. Observing animals where they feel comfortable and relaxed together with the owners, students felt that they could be able to see them as living beings with individual characteristics, tastes, preferences and habits. Developing such a close and deep understanding of their users, students could not only better empathize with the users, but also got emotionally engaged with the design project. The feeling of achievement in empathizing with the user and emotional engagement in the project supported the feelings of satisfaction and pleasure among students. Particularly observing that animals interact with the products in the way they expect, students believe that their designs are understood and ‘accepted’ by their users, and they contributed to their users’ well-being through design.

Third, as design educators, this project provided us with a unique opportunity to (1) broaden our conceptualization of ‘user-centeredness’ in design, and (2) reflect on and reconsider how we guide our students in understanding the user in different stages of design projects. In this, strong collaboration with experts who study animal behavior was invaluable. Particularly coming together and discussing the focus of the project together before the project starts was important to learn their key concerns regarding animal well-being, and to get familiar with the vocabulary they use. In these meetings, for example, we noticed that frustration is an important emotion of animal that needed to be taken into account by designers who design for domestic dogs and cats. As the design problems of the 21st century are getting more complex and multi-layered, interdisciplinary collaboration has become a key aspect design teams in professional practice (Dykes et al., 2009; Feast, 2012). This research showed us how academic expertise of different fields of science and technology, with which we do not often consider design practice related, can make a unique contribution to students’ learning experiences by placing emphasis on user research rather than marketing- or manufacturing-related aspects of the design process. In light of our findings, we underline the significance of seeking diversity in the expertise fields and types of the partners in collaborative design education projects. Such a diversity not only helps design educators to focus on different stages and aspects of the design process in various projects, but may also support students’ self-exploration of their own skills, interests and tendencies as future design professionals.

Conclusion

In a territory where products for animals are mainly developed for the purpose of enhancing their interaction with humans, and where limited solutions exist on improving their holistic well-being, this design studio project can be considered a small but unique step to raise awareness towards animal well-being in design field. In our design studio project, within the three-stage user research model we developed, we received much support from facilitators such as experts and owners to make sense of animal behavior. In addition to exploring the role of facilitators further, how the students can interpret animals’ behavior in terms of their interaction with the designed object without the presence of such facilitators is a good question worth investigating in further design studies. Certain objective observation mediums which are indicated by Hirskyj-Douglas et al. (2017), such as eye trackers and sensors, can be incorporated in such a design studio project to assist the trial processes. As also suggested by our students in the interviews, longitudinal research with users can provide designers with the opportunity of creating more room for the participation of animals as users in the design process.

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A Case Study of Game-Based Learning in Interior Design Studios

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Abstract

The purpose of this paper is to understand perceptions of interior design students after using game-based learning (GBL) as an approach to address workload distribution, lack of clear assessment criteria, and deficiencies of the master-apprentice model during the process of solving several small-scale design problems along the course of a semester. A literature review of the instructional issues in design studios is presented along with an overview of the activity systems theory as an underpinning theoretical perspective. This research paper explains the research design behind the case study methodology used to perform data collection, analysis measures and organize coding schemes. Findings from the study conclude that GBL fits into the iterative and experimental nature of the design process, helps students focus on the design process through trial and error without a significant risk, changes the studio's feedback structure, and allows students to track their progress while having creative freedom. This paper provides empirical evidence supporting the existence of instructional issues in traditional design studios, provides considerations for using GBL to address these issues, and suggests directions for future research studies in fields of instructional technology, design pedagogy and higher education policy.

Keywords

game-based learning, design education, studio pedagogy, studio issues, technology, case study

Introduction

Interior design educational studios are environments for active learning and experimentation. However, they have been generally criticized for shortcomings in basic pedagogy. This qualitative case study attempts to understand the perceptions of six undergraduate interior design students about using game-based learning (GBL) in a 16-week long design media and presentation studio. This paper focuses on explaining the research design, data collection, analysis methods and coding procedures, and limitations. It finally delves into findings and GBL implementation considerations through referring to participant quotes. This case study attempts to answer the following research questions:

- How do interior design students perceive GBL as an approach to address workload distribution, lack of clear assessment criteria, and deficiencies of the master-apprentice model?
- How do the perceptions of these students confirm general affordances of GBL within interior design studios?

Literature Review

Issues in Traditional Studios

The design process within the design studio dictates the sequence traditionally practiced by design educators (Broadfoot & Bennett, 2003; Kuhn, 2001). Students tackle open-ended, ill-structured problems usually presented as project descriptions. The number of projects students complete within each studio differs greatly depending on their academic year and studio topic. Entry level and drawing media studios usually include 2-4 short projects, 2-4 weeks long each. Advanced level studios usually include 1-2 large projects, 6-10 weeks long each (Al-Qawasmi, 2005; Chui, 2010; Ham & Schnabel, 2011). However, this traditional format has been criticized for issues with student workload distribution, deficiencies with the master-apprentice model, and the unclarity of assessment measures used to evaluate student work. Student workload distribution has been questioned in design studios due to amount of time allocated for the studio sessions within the curriculum (Smith, 2015). Confining students to perform their design thinking and acts of creativity within the studio's space and time proved ineffective (Kuhn, 2001). The misalignment between time allotted for studio sessions and the workload distribution expected from students is obvious according to recent studies (Belluigi, 2016; Dorta, Kinayoglu, & Boudhraâ, 2016; Ku, 2016; Smith, 2015).

Using the master-apprentice model places pressure on instructors to attend to all students individually (Collins & Kapur, 2014). This may encourage a sense of *following* of the instructor, and misinform the educational process when instructors try to conceal the design procedure to arrive at final solutions or products (Glasser, 2000; Yurtkuran & Taneli, 2013).

Creativity in design studios is important for it nurtures innovation and individuality among students. However, traditional design studios view creativity as the only important skills to cultivate and gains exaggerated emphasis compared to other aspects of the learning experience in design studios (Gross & Do, 1997). This increases subjectivity in evaluating student work, and makes grades an incomprehensive measure of work quality (Smith, 2013, 2015).

Theoretical Perspective: Activity System Theory

The design studio, as a learning environment, can adapt to several theoretical perspectives. For this study, I used the activity systems theory developed by Engestrom to analyze the studio environment into identified yet integrated entities; participants, a sense of community, and a set of engaging activities (Engestrom, 2000). The design of the GBL studio was also based on the activity system theory. The activity system comes to life within the studio when participants are involved in tasks that facilitate prior knowledge and experiences. Participants in the design studio are active contributors to and creators of knowledge, content, context, and perceptions.

The activities can be categorized into those requiring physical skills such as construction and artistic expression, and those requiring cognitive skills such as communication and inquiry (Dewey, 1915). Figure 1 illustrates GBL as a pedagogical approach that can provide a structuring framework for these activities while increasing students' engagement, extending lines of communication, and enhancing decision-making processes.

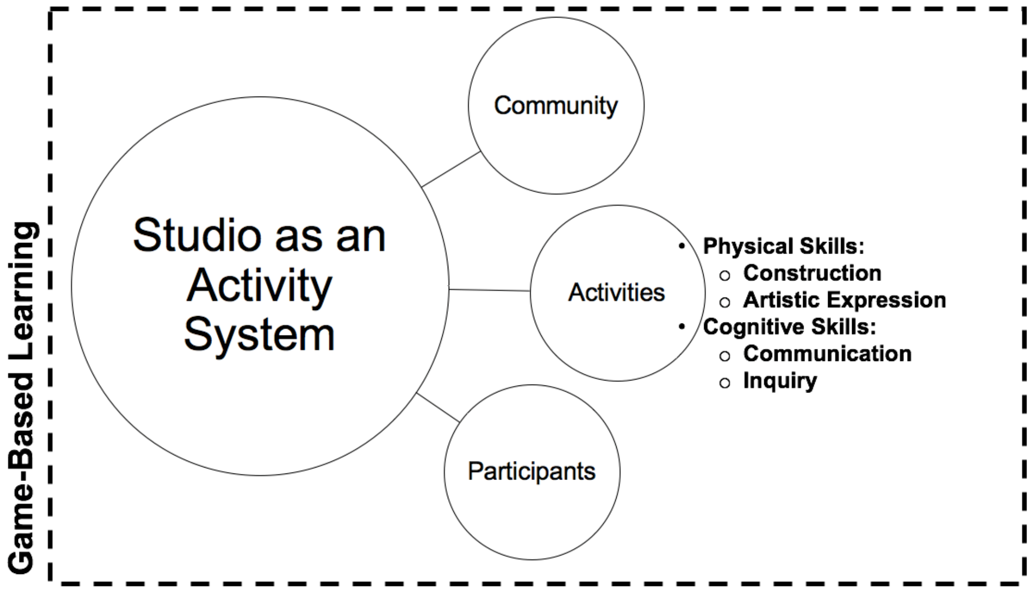

Figure 1: Game-based learning approaches as a framework for the studio's activity system.

Affordances of GBL

This case study adopted Karl Kapp's definition of GBL where game-like elements and attributes are used in a meaningful manner to design a course in game-like structure to promote learning and engagement (Kapp, 2012). GBL has been found to; cultivate better learning attitudes, increase student motivation, nurture higher-order thinking and decision-making processes, situate and authenticate the learning experience, and help achieve better learning outcomes (Kapp, 2012; Nelson & Annetta, 2016; Perrotta, Featherstone, Aston, & Houghton, 2013). This study used GBL approaches to establish a structure for the activity system within the design studio. Elements and attributes of GBL increase student engagement and nurture skills acquisition through structuring the studios tasks and actions.

Gee (2004) suggested that GBL is built upon several learning principles; some of which can address instructional issues pertaining to traditional design studios. In both GBL and traditional studio settings, learning is situated in practicing knowledge. The experiential nature of learning in these environments reduces stress associated with fear of failure when trying new approaches. The iterative learning process in GBL environments is like the learning cycle in design studios. The nonlinearity of the design process is like the multiple problem-solving routes available in GBL. Finally, the learning experience in both environments is based within the learner, the learning environment, and the community of learners.

Current research and applications on GBL are very well developed in the K-12 sector (Denham, Mayben, & Boman, 2016). The higher education sector has witnessed successful and insightful applications and research studies as well (Brown, Comunale, Wigdahl, & Urdaneta-Hartmann, 2018). However, most of these applications have been in disciplines other than design, in general, and none of these applications were in relation to studio environments or the field of interior design specifically. This study aims to investigate the application of GBL in a discipline that is more connected to design studios as they manifest specifically in interior design and generally in fields such as architecture, landscape architecture, urban planning, or graphic design.

Overview of Research Design

A case study methodology was adopted to study how six undergraduate interior design students use and perceive GBL as a supplemental approach to solve design problems in a studio. The design of this case study was based on the activity systems theory in that the techniques used to collect and analyze data were considered the tools of the study. The Instructor/ PI, the learners and the GBL system were playing the role of the subjects or actors, while the themes and assertions were considered the objects/ motives of the study. The participants/ learners and their belonging to an interior design program formed the community component. The rules of engaging in the study were voluntary participation, along with individual 3-hour commitment from each learner/ participant. Finally, the divisions of labor were the hierarchy of the studio environment, and the responsibilities held by the study’s subjects. Figure 2 illustrates how Engstrom’s representation of a collective activity system informed the research design of this case study.

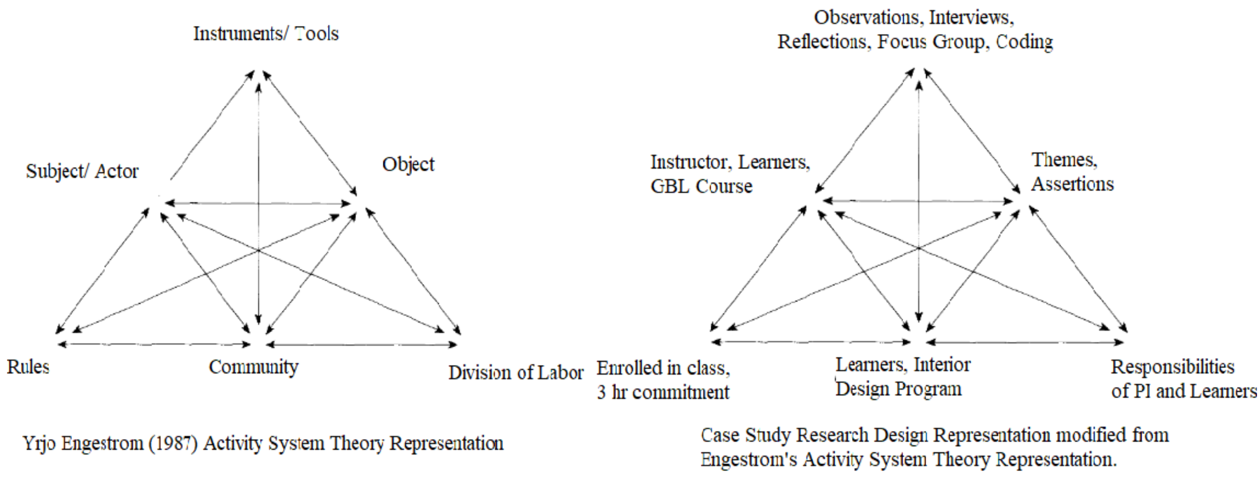

Figure 2: Representation of both the original Activity theory figure developed by Engestrom (1987) and a modified version depicting the research design of the GBL case study.

The students used a GBL approach the instructor (Principal Investigator) designed to navigate the design process in several small projects. The course I designed for this study was based on the experiential learning theory model (Kolb, 2014) to align instructional design practices with game-based learning elements and attributes, while keeping with the spirit of the design studio structure.

The course was a 3-credit hour studio addressing the application of various media techniques for the presentation of interior design projects. The course met twice a week for 3 hours. The course used a GBL pedagogy and was designed as a game structure. Students were introduced to four challenges; each challenge had an assigned list of in-class quests and Homequests. In-class quests were timed activities and needed to be completed during the studio, while Homequests were activities that should be completed outside of the studio. In-class quests were designed to help students progress through the course without leaving too much work to do outside of class time.

The instructor observed and took notes of participants while working through design problems. Each participant was interviewed individually to reflect upon and clarify his or her experiences using the GBL approach. Interview questions focused on understanding perceptions of GBL as an approach to address workload distribution, assessment ambiguity, and master-apprentice model deficiencies. The focus group session debriefed participants to provide insights on improvements needed to enhance the proposed GBL studio and how their perceptions confirm general affordances of GBL within interior design studios.

It is worthy to note that the researcher is also the instructor of the course used in the case study. As a researcher, I have my biases in terms of the findings I expect from the study and I need to be clear in differentiating what I would like the data to convey versus what it truly does convey. As an interior designer, I have biases in terms of my design style and approach. I tend to use inductive logic when thinking about design solutions, where I start from the specifics of the problem statement and progress systematically to the general and overall solution. And as an interior design educator, I have biases in terms of what I view as appropriate or correct design processes.

Unit of Study

Bridging the case study methodology with the Activity System's theory is manifested through using the participants "Activity" as the unit of analysis for this study. The activities that the participants engaged in can be categorized into:

- Developing design solutions for the projects on hand using the tools provided as individuals and as a community of learners.
- Employing the reward system of the game-based learning studio to encourage task completion in and outside of class
- Enabling their flexibility to take on a variety of learning roles

Sample and Demographics

The study used criterion and convenience sampling (Bloomberg & Volpe, 2015) to recruit six undergraduate interior design students at a public University enrolled in an interior design studio. The instructor introduced the study using brief explanatory leaflets. Students' questions about participation were answered prior to joining the study. The main criteria used for recruiting the participants were their willingness to participate in the study, their enrollment in a junior level studio, and their time commitment of 3 hours for individual interviewing and focus group session. Proper Institutional Review Board (IRB) consent forms were ndistributed to all students in the class; those willing and interested in participation signed and returned the forms. The study lasted for the duration of the fall semester where students and the instructor met 3 hours twice a week at a dedicated studio space within the university campus. The demographics of the participants can be summarized in Table 1.

Table 1

Sample demographics data

Demographic	Category and Percentage			
Age	20	21	22	23
	16.66%	16.66%	50%	16.66%
Race	White		African American	
	67%		33%	
Program Year	Junior		Senior	
	83%		17%	
Gender	Female		Male	
	83%		17%	

Data collection

Data was collected using observations, interviews, written artefacts, and a focus group session. Observations were used to document participants' progress through the design activity. During the working sessions, the instructor collected observation notes in a digital format and reflected on each session as soon as it ended. Notes were also taken of student's comments, feedback and nuances that occurred during the weekly studio sessions. Weekly reflections were collected from students and used to inform interview questions. During the semester, semi-structured 30-minute individual in-depth interviews were conducted with the participants to illuminate the notes made during the observations. Interviews were recorded using two electronic devices to ensure having multiple recordings. Minimal notes were taken while conducting the interview to ensure maintaining rapport with the participants. In the focus group session, participants discussed their perceptions during various design stages. The focus group helped participants brainstorm about ways to improve the GBL pedagogy in interior design studios.

Data Analysis

The analysis took a progressive focusing approach (Parlett & Hamilton, 1972). Observation notes and weekly student reflections were continuously analyzed to inform interview questions. In-depth interviews were then transcribed and analyzed to inform focus group questions. The analysis structure was open to change and enhancement as the study continued. The progressive focusing approach allowed principal investigator to interact with the data as it was collected, and helped re-focus and refine data collection continuously.

Attribute coding was used to help organize the data. Codes were organized and connected to data formats. Data was coded per participant and identified with their corresponding interview session number and date, focus group comments, and weekly reflective writing document. Structural coding was later used to organize participant responses for each interview question, and then relate them to answering the main research questions. This coding method allowed for quick access to data that was relevant to a particular analysis from the larger data set (Namey, Guest, Thairu, & Johnson, 2008). In-vivo coding was also used for interview and focus group transcriptions (Saldana, 2015).

Finally, the data was comprehensively reviewed using pattern and focused coding to produce themes and assertions that inform and address research questions. Making sense and meaning of data took place during the theming stage, where codes were synthesized to formulate categories, then themes that were later used to create assertions. These assertions eventually addressed the main research questions of the study. The results of data analysis lead to a broad interpretation to illuminate the unique case of GBL in interior design studios. Also, the findings discussed lessons learned to inform the development and enhancement of the proposed GBL pedagogical approach.

Findings and Discussion

After analyzing the data, codes were organized using thematic analysis. The thematic analysis approach was found suitable for this study because it helped align the data with the two main research questions. The flexibility and independence of this approach helped uncover patterns among the study's units of analysis, and allowed the development of latent themes beyond what the data merely showed at the semantic level. Braun & Clarke's (2006) 6-step framework was followed to arrive at five major themes. The first three inform the study's first research question. The last two themes address the second research question, provide supporting evidence of GBL affordances in interior design studios, and reiterate student reported issues in traditional design studios.

Theme 1: GBL Addressing Workload Distribution

This theme condensed information from five code categories addressing the students' design thinking process, progress and motivation, and how GBL impacted their time management.

During the interviews and the focus group session, students noted how they see the design process during the game-based studio as an iterative process. In their reflection papers, they described their design thinking in a continuum between trying and struggling, to rearranging their solutions and drawing from external inspirational resources:

> "I have been struggling trying to figure out what all to put on my board. I have literally rearranged my board layout at least ten times and I am still not happy with it."
>
> "I started with sketches related to that and draw on some inspiration …. change my direction and go with a theme that suited my project better."

Students also noted that within the game-based studio, they had the chance to think deeper and earlier about their projects. One student focused on how the GBL approach allowed her to focus on the design process and take risks with her creativity because she was "not trying to do it to get it correct, like I'm just doing it to like experiment, see what works".

Students noted that using GBL reduced their tendency to procrastinate. The in-class and home quests kept students flowing through the projects. Staying on task became easier given they had activities due every class. The continuous, consistent, weekly checkpoints obligated students to complete their activities on time and not get behind:

> "I found myself doing, staying on task a lot more and not like just waiting to the weekend to do it."
>
> "I liked how you had different aspects due one at a time, that way we could stay on track and work on one and that way it's not cramming it all at the end trying to finish. We had to stay on top of it."

The GBL approach also influenced the structure of the design process. Students commented on how they found the defined structure of each project useful along with the corresponding due dates to individual activities. They also enjoyed having creative freedom, despite the structured nature of the course:

> "My favorite part about this course compared to other classes is that you did not force us to do anything we didn't like. I liked having creative freedom to do what I wanted for a change."
>
> "I did like that our projects had structures and due dates, and I felt they were more open ended…. with this course I was able to see my own design develop"

Students found that the timeline used for the course aligned well with the design process. All the course activities and elements worked together to guide students throughout the different projects in a gradual manner. Using tutorial demonstrations or a short lecture before working on activities in each class introduced students to what was expected. The Homequests connected the class meetings between different weeks and gave students the chance to apply knowledge on their own time.

> "we go like step by step instead of just saying like design is a whole-time thing"

> “I think like the way you had the time, I’d say what we had to do our research first and we had that week to get that in. Then do our selections next and that first week was focused on the research it wasn’t focused on doing selections”

When students were asked if GBL impacted their time management during the studio, two did not see it as impactful. One viewed the checkpoints as regular due dates, the quests as traditional assignments, and the rewards as their traditional grades.

> “because when you are in college you are just like, you are like okay that’s a due date got to do it then. I didn’t necessarily look at it like any other way if that makes. I just did it, that didn’t affect it I don’t think. I don’t think it affected my time management. Because versus a normal thing, it would have just been like basically the same thing just not worded that way”

The second student focused on how GBL was not efficient for him as a full-time employee, where his busy work and school schedule kept him from keeping up with the required checkpoints, quests, and achieving the rewards:

> “The approach maybe didn’t work so much for me personally. If I was more a traditional college student who didn’t really have to work because I had help from my parents to pay for all my bills and everything, then yeah, I’d be. As a less traditional college student, it was a little more challenging to keep up with.”

The other four students thought that GBL made the studio easy going and not as stressful. It allowed them to stay ahead of schedule by becoming more conscious of how they spend their time in studio. They became more patient with their design thinking, managed their effort and time, and could gradually perfect the design process and product.

> “I have been ahead of schedule. I worked almost every day on my Moroccan board and it allowed to me to be pretty stress free.”

> “I became more conscious of my time and what I needed to spend my time doing to finish the project.”

> “I think this project will come out neat. I don’t want it to look rushed so I want to perfect it and do my best in the given time.”

> “I don’t feel as rushed, and that has to do with check points, and incentives for meeting those check points. It’s helping me be more disciplined, and not push it off to the weekend.”

Theme 2: Achievements and Rewards

Students used a variety of mechanisms to track their performance and achievement throughout the studio. They also used these tools to receive feedback about their performance without needing to meet face-to-face with the instructor or waiting till midterms to know how well they are doing. Students used a combination of tools related to GBL, and others inherent within the learning management system to facilitate the course.

Leaderboard.

Students used the Leaderboard tool to view their ranking among the rest of the class (Figure 3). They found the leaderboard useful because it provided anonymous and indirect feedback on their performance in the class relevant to other students. They also found it motivating for them to try and improve their performance within individual areas of the course. Each category was in a separate column. Therefore, it provided another view of the performance in addition to the overall course score available via the learning management system.

> "I definitely look at [Leaderboard]. I think it's very helpful. So, if I'm in 5th place, I need to put a little fire and get it together. I look at that before I actually look at like the grades."
>
> "my favorite is the [Leaderboard], I can see where I am in relation to other people."

ID	Total Points	Total Percentage	Rank/ Place	Attendance	In Class Quests	HomeQuests	Challenge 1	Challenge 2
14400	613.5	61.35%	1	0	58.8	51.8	190.5	132
48364	412.7	41.27%	8	-10	41.8	27.5	91	141
60426	519.2	51.92%	7	-15	50.45	51.7	156.25	103
95932	602.4	60.24%	4	-10	57.6	47.8	180	134
04072	588.65	58.87%	5	-5	60.85	27.8	173	141
08110	611.75	61.18%	3	0	57.75	34.5	195.5	126
14720	612.3	61.23%	2	-15	58.7	59	191	136
32317	571.1	57.11%	6	-10	58.3	56	141	139

Figure 3: Leaderboard tool developed using Microsoft Excel and imbedded within the learning management system

Badges.

The course used digital badges to reward and incentivize students (Figure 4). Students had mixed feedback about badges in the course. Although they thought the badges added an enjoyable element to the course, they could not see the necessity or value behind them in terms of evaluating performance in the course. Using the badges as merely virtual rewards was not a strong enough reason for employing them as an achievement tracking mechanism:

"I like them though! I am a very competitive person and I want to win at everything. But I really like the leaderboard. I made a point to check it all the time."

"I think the badges they are fun. They don't necessarily make me work more. But, they are fun to see."

Figure 4: Digital badges used in the course to reward students work.

Rubrics.

Students were provided with rubrics to have a clear idea of the criteria used to evaluate their work. They mentioned using rubrics to identify how many points each activity was worth, what areas to focus in the project, to understand project expectations, and to provide self-review on their work.

> "The rubric [was]useful, because if something is worth 20 points, and then something is worth 5 point, you know what to focus on more."

> "I love rubrics because I can know before I start what you're looking for. Where my points are coming from, you know, within their there is a lot of points and you know I really focus on that."

My Grades.

This is a tool is inherent within the learning management system used for the course (Figure 5). Students used "My Grades" to know how many points they achieved or missed for each individual activity. It also allows them to view all their graded activities in one page and displays the status of grading for each item (in progress, graded). It finally allows them to view comments and feedback the instructor documented on their work.

> "I just always check my grades, because I'll be like why do I have a zero in this grade? What did I not do? Or, just kind of keeps you updated."

> "I check my grades on blackboard because you've just seen exactly what you made."

ITEM	LAST ACTIVITY	GRADE
Weighted Total View Description Grading Criteria		-
Total View Description Grading Criteria		-
HomeQuest 1 DUE: AUG 29, 2016 Assignment	UPCOMING	- /5
HomeQuest 4 DUE: SEP 12, 2016 Assignment	UPCOMING	- /5
HomeQuest 5 DUE: SEP 14, 2016 Assignment	UPCOMING	- /5

Figure 5: My Grades tool in Blackboard Learn displaying quests and respective points.

Calendar and timeline.

Although this is not a tool that was intentionally designed or used to track students' achievement in the course, some students mentioned using the calendar to track weekly studio activities and their corresponding due dates. One student explained how using both the calendar and the timeline helped her:

> "The tool that I use to keep up with stuff in class is "Calendar" in Blackboard. I go to calendar and it shows what's due that day. I have my planner and I'll write on each day what's due that day and then at the bottom write what I should work on that day to be where I am supposed to be. So every day I'll get done what I have on there and look at it. I'll plan it for like the whole week and if I stick to that like I'll be done with everything on time and that way I don't stress myself."

Theme 3: Learning Roles

Within the game-based studio environment, the roles adopted by students and instructors change to better suit the learning experience on hand. The learners' role developed and adapted through several phases during the 16-week period of the semester. At the beginning of the semester, students discussed how they felt skeptical about the GBL approach and towards trying to immerse themselves into the experience.

> "At first my role was like a deer in headlights. I felt lost and like I don't know where I am going with this."

> "a lot of us at first were hesitant on how we felt about it because it was just kind of a new structure."

Towards the end of the semester, students found themselves more encouraged to take initiative in their learning. They felt that they can be responsible for searching for answers to their questions, encouraged to leave the comfort zone to try new ways of learning, and be less critical of their unfamiliarity with the new knowledge they are gaining:

> "when we got to Sketch Up towards the end of the semester I think I have progressed in that way in taking it upon myself more."

> "once we actually started putting our foot in I felt I need to change my role and be responsible for figuring out how things work. I felt my role was to take initiative and search for answers to my questions. I am not going to always have someone beside me to answer my questions."

When reflecting on how their roles changes as students during the focus group session and the individual interviews, students shared some ways that they could have done things differently during the course to improve their learning experience. One student mentioned that she should have taken more notes or recorded the lectures and demonstrations in class. Another student discussed how she would have liked to increase her effort and improve her work quality. Finally, one other student wished she was more open and embracing of the different way of learning introduced in the class.

> "I actually wish I would have taken more notes than I did to utilize it. I felt like I should have recorded the lectures and stuff, especially for Photoshop."

> "I wish I would have paid attention from the beginning of what the overall project was going to be."

> "Be a little more open minded to it because even though it was new and I was trying to learn it …. I didn't like push myself at the beginning"

Students also shared how they viewed the instructor's role during the game-based studio, and how it changed depending on the nature of the project on hand. The role of the instructor was within a continuum between being hands-on and hand-off. Students explained that when they needed step-by-step and detailed guidance through their projects, they found the instructor involved within their learning experience. They focused on how the instructor goes around the studio space, shows them techniques through in class demonstration, checks on their work, and keeps students on track by reminding of important due dates, checkpoints, and explaining intricacies of the GBL approach:

> "in the beginning I felt like it was more, more hands-on"

> "I feel the instructors really involved … like whenever we're doing rending like showing those techniques and working around and making sure we understand what we're doing."

> "when we watched instructor on the computer and just followed along. That is probably just the best way for us when we are going through the learning process. It's just doing there, hands on where we can ask questions and be able to work things out while we are there in class."

On the other end of the continuum, students found the instructor to be more hands off. They explained that they appreciated having time and space to think through problems in class while the instructor is there for them when needed. One student discussed how she found the instructor to be "not the traditional teacher… not just talking at us all the time." She referred to the instructor as a "tool" that students can employ to facilitate their learning.

> "[the instructor] was hands off for the most part so we can have work days in class which I really do appreciate because if I am working on something at home and I get stuck, I put it away and procrastinate and then I am behind. But in class I liked having her there to help us along the way."

> "I guess it's a more hands-off approach for me, I like that instructor's around to definitely give us instructions. I don't feel like I'm doing this blindly, but at the same time, I don't feel like instructor's hovering over me. Just there like as a tool but not necessarily."

Theme 4: Affordances of GBL in Design Studios

This theme summarizes categories of codes that represent the affordances of using GBL within interior design studios. Per the data collected from students, GBL helped provide opportunities for authentic learning, prior knowledge facilitation, and social interactions. Students found that GBL immerses them in an environment of experiential learning; where they learn through experimenting with a variety of design strategies and communication methods.

> "it's actually refreshing that we actually learn something this semester that we can actually apply in our field"

> "even though this is a game. I feel I could apply it more to a different world of experience because it's more there's deadlines and checkpoints to get through them. So I think that gets more applicable to the real world."

> "structured on how it's going to be in real life when you have couple of days to put materials together when you have a client walk in. I think it helped to give it a better structure that is more realistic and how to get it out in the field. Based on my experience while working at furniture marketing."

Within their weekly reflections, students discussed how the challenges within the studio facilitated prior knowledge from previous semesters. In-class quests and Homequests helped familiarize students with several skills they had forgotten. The quests within each challenge also helped them overcome their fear of previous failing attempts, and guided them to complete the activities of the studio:

> "Doing this project has helped me a lot with remembering how to do things in that we did last year in another class"

> "I learned a little bit last year when we were doing it for our residential class but it has been so long that I already forgot so much. I'm glad we worked through some of the exercises in class together because I would have been so lost."

Students in this cohort have described themselves as being called the "quiet group" among other students in the program. Their social interactions were minimal at the beginning of the semester, and almost no interactions took place that are related to their work in the studio. During the interviews and the within their weekly reflections, students discussed how they see their social group dynamics changing in the class. Their attendance at the senior's cohort presentation was built into the GBL studio as an opportunity for authentic learning. Observations of the class showed that the participants started talking more amongst themselves and discussed as a group their thoughts for their project's final presentation. The students' in class collaboration helped address their questions faster than waiting in turn for a one-to-one consultation with the instructor:

> "I'm also glad that we got take a break from all the classwork one day and see what the seniors were up to. Seeing their projects also got me to thinking about my wedding project and how I wanted it to turn out."

During the focus group session, students also discussed how they have started to feel like a family within the class. They mentioned feeling responsible towards keeping each other updated about classes and becoming more comfortable about asking each other for help outside and inside the class.

> "I think this semester we got more comfortable with each other and our social interaction increased significantly compared to prior semesters."

Interestingly, one student explained that the social bond that has been developed among her cohort is of more importance to her than the quality of the education she receives at the program. She further discussed that the social collaboration and interaction among students in her cohort makes up for what is missed in class:

> “the social aspect of the program is more important than the gaps that have been in some of the courses, because of newer instructors. Yeah, because I feel like even if you don’t get it from the teachers, whereas this classmate might understand it better, and can teach you like helped you.”

Students also focused during their interviews on how GBL has been part of student conversations outside and inside of class. GBL became another way for students to update each other on important due dates, and collaborate to help one another compete in a friendly manner without compromising their relationship as individuals or their quality of work:

> “I mean we were all intrigued about it. their badges and stuff they get like whenever somebody goes on and checks a badge it's like, “Oh! I got a little badge.” We get to be silly over this little badge we’ve gotten and it's a little fun.”

> “even though the projects are individual like we’re all doing the same thing and so, it like kind of promotes collaboration to an extent or like a discussion of our ideas, and I think that that has something to do with GBL. Because we’re all directly competing against one another but like in a friendly manner.”

Theme 5: Traditional Studios

This theme discusses two categories of codes related to traditional design studios including affordances and issues. The affordances of design studios in general are concerned with the Uniqueness of the educational setting when compared to traditional lecture format classes. Students explained how they prefer the studio format over traditional lecture format classes for a variety of reasons; the nature of hands-on work that is usually required in a studio setting, the small size of classes, the lack of formality in the program, and the strong relationship between students and instructors.

> “I like design studios better than the courses because it’s hands on”

> “a positive is how laid back it is here. you can come and go as you need it’s like a little, your own little house. You are close to the teachers because you have such a small group too, I love it so much.”

> “you don’t feel uneasy about anything. You don’t feel weird about asking the questions, or calling or texting you, emailing you at any time trying to figure stuff out. I feel like other majors that’s not the case”

Students also discussed their experiences with previous studios and the type of issues they usually face. The first issue that seemed to receive consensus among the participants was lack of creative freedom. Students shared that in design studios, they do not usually have the freedom to change thinking direction or design theme as the project progresses. They are also obliged to include very specific and standardizing details within the project to a degree where they feel detached from their own designs:

> "I feel in other classes we are obliged to include very specific things which makes me feel the design is not really mine."

A second issue that students face in design studios is the lack of clear instructions on how to move through projects. Students mentioned that they usually get told what to do, without any guidance on how to arrive at suitable solutions, and without consistent feedback for them to know if the solutions they arrived at are correct or acceptable.

> "other times we had projects… So, it was like, "Okay this what our project is, start thinking about your materials and then we'll work on a project as we go along."

> "In other courses I feel like design is a whole-time thing, and not really a process"

> "some of our courses they just, they [say] do this and don't necessarily help you or check on your progress."

Another issue that students discussed, and is more specific to their program, is the frequency of changing instructors. Due to the small size of the program, students are not provided with several full-time faculty. Instead, the program depends on part-time or adjunct faculty that deliver courses based on availability and need. This has impacted the participants view and experience of their design education journey. The lack of permanent faculty members made students feel less of a priority, shook their confidence in the education they receive, and caused them to question their ability to learn.

The last issue students discussed with regards to design studios is time management and workload distribution. Students shared that although the studio sessions are long, they see it as a chance for instructors to ask and expect more work, and therefore increase the expected homework hours. Students tend to feel rushed in studios with majority of the work to be done outside studios hours. Hence, the learning process remains not very detailed and causes students to focus on just completing the assignment regardless of the quality or thinking processes behind the activities:

> "our program's homework hours are exponentially greater than college of business, journalism any of those."

> "at the studio, the time period is long, it's almost like a 3-hour class, I still feel like there's so much to learn in that time."

Conclusions

The experiential aspect of GBL matches the iterative and experimental nature of the design process. GBL helps student focus on the design process by allowing them time and room to think, explore, fail, and succeed without a significant risk of penalty. This impacts the feedback nature adopted within the studio environment. Clear expectations for the multiple formative feedback sessions throughout the semester allow students to remain on track with the projects, while having creative freedom to explore ideas without fear of failure.

The GBL approach did not only impact how students thought about their projects, but also how they progressed throughout the design process. Providing students with tools to succeed is only one part of the equation. Students should also invest time and effort into using these tools to achieve the expected learning outcomes by the specified checkpoints and be immersed in the learning experience.

With learning styles and preferences, it is important to use multiple ways for students to track their performance and to be able to review feedback when they need it. This is particularly important when implementing GBL in higher level studios, where students work on one large project during the semester. GBL can be used to establish continuous performance feedback loops. Students can have a chance to improve their performance instead of waiting for major project critiques where risk and fear of failure is higher.

Changing roles in GBL studios is another important consideration. While this may put both the instructor and the students outside of their comfort zone, it encourages them to adapt to rapidly changing situations which is a skill highly recognized in professional careers.

GBL in interior design studios can be implemented to enhance several aspects of the studio community and instruction. This study showed that GBL helped students see realistic application of interior design knowledge and theory. GBL mimicked schedules and deadlines expected in the field, activated knowledge gained in previous courses, and increased student interaction during and outside of the class time.

Finally, students confirmed the instructional problems in design studios that are the focus of the study, including the imbalance between workload distribution and time management the high dependency on the master apprentice model, and the lack of clear guidance on expectations and progress of the design process.

With the shift in design studio pedagogy towards using digital technological advancements in the process and product of design, the application of innovative learning technologies within educational settings cannot be overlooked. The 2019 Innovating Pedagogy Report from the Open University places “Playful Learning” as the top pedagogical trend that is in substantial formation and will continue to be for the foreseeable future (Ferguson et al., 2019). In addition, the report specifically identifies a need for more evidence on approaches that can guide learners through their playful exploration. The findings of this case study can be used as a starting point to build up the complexity of learning support system for learners and educators. This case study used a digital learning management system, whereas there is a plethora of opportunities for designing and developing game-based learning environments for a variety of disciplines and creative interests.

Limitations and Future Directions

The restricted sample size and sampling method contributed to narrowing the study's focus and reducing its transferability. As for methods of data collection, observations may hinder participants from acting naturally. The instructor took notes at the instructor's podium periodically during class time instead of at students' desks. The focus group brought on several limitations. Some participants' opinions were overpowering others or altering the discussion's path. All participants were addressed for each question, and responses were prompted when changes in body language happened (i.e. Nodding). Participants were required to identify themselves with a number and to say the number out loud before answering any questions. When a participant forgot to mention their number, a note was made next to the question with that participant's number and time. This smoothed the transcription process.

Several future research studies could be developed based on this case study. The limitations that the learning management system used in the study caused can be addressed in several ways. Future studies might delve into exploring GBL in design studios using different management systems or independent game structures.

This case study shed light on a small number of participants without comparing between traditional and game-based studios. It would be interesting to collect evidence on both learning environments by conducting a comparative case study, where student perceptions about GBL in one design studio can be compared to their perceptions in a traditional design studio.

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Constructivist Digital Design Studio with Extended Reality for Effective Design Pedagogy

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Abstract

It is evident from previous research that learner preference, cognitive load and effective learning are interconnected. Designers' individual characteristics and preferred modality of information delivery in the design studio has direct relation to the effective use of the information delivered. This study evaluates and discusses possibilities of using XR (Extended Reality) technology within the framework of constructivist learning approach in the interior design studio by measuring its effectiveness as a pedagogical tool. The nature of the design studio and its pedagogy stayed nearly analogous throughout the past century (Bashier, 2014; Koch, 2006). The exponential advancement of information, communication technologies and generation Z's assertiveness toward electronic 'device' oriented lifestyle are the two major challenges that today's design studios yet to adopt for effective design education. With an overview of contemporary design pedagogy and the potential use of XR for a constructivist learning environment; this study explores students' learning styles and identifies how these learning preferences affect their learning outcome in traditional and Extended Reality based learning environment.

Keywords

design studio instructions; traditional method; extended reality; learning styles; learning outcome

Introduction

Design education in this digital age is facing major challenges to bridge the gap between conventional design education and generation Z's learning preferences. This is due to the unimaginable pace of advancement of technology and its recent shift from the *Information Age* to *Experience Age* (Wadhera, 2016). Designers are unique in their creative thinking and ideation process, synthesizing information, constructing new knowledge and are explicitly influenced by gender, culture, background, cognitive style, available technology and exposure to the outside world (Baer, 1997; Baer & Kaufman, 2008; Gül, Gu, & Maher, 2008; Hu-Au & Lee, 2017; Lubart, 1999; Pearsall, Ellis, & Evans, 2008; Shalley, Zhou, & Oldham, 2004; Wolfradt & Pretz, 2001). Previous researches have shown that efficient use of design modality and its interface is dependent on the user preferences; therefore strongly contributes to effective learning. Effective learning in a design studio largely relies on the effective communication of design ideas and the relationship among learners' preferences and instruction modality (Demirbaş & Demirkan, 2003). In general, design pedagogy is founded on Euclidean understanding of form and space that teaches "descriptive geometry" (Lee & Reekie, 1945), theory and application of artifacts to occupy and involve human activity. But the advancement and inclusivity of technologies in all aspects of generation Z's '*device'* oriented lifestyle presents new challenges for design education. Constructivist teaching and learning method is often considered to be one of the techniques that integrate different pedagogy and epistemological methods in education. Enough studies are not available that explored the potential of teaching in design students using Extended Reality platform within the framework of constructivist learning. Extended Reality is relatively new platform that incorporates characteristics of VR (Virtual Reality), AR (Augmented Reality) and Mixed Reality (MR). VR is an immersive, simulated three-dimensional environment (Bryson, 1995), AR overlays digital (augmented) geometry in the physical environment where the task is performed (Fischer, Bartz, & Strasser, 2005) and MR anchors digital contents in the real world where users can perceive both physical and digital objects simultaneously.

The purpose of this study is to explore how learner preferences affect the use of traditional and Extended Reality-based information delivery method for constructivist learning in the design studio. Several studies investigated the process and implications of virtual environments in design communication and presentation; however, a vacuum exists in knowledge regarding how technology-based information delivery method affect the cognitive process of learning in a constructivist design studio. A modified technology acceptance model (TAM) questionnaire (Fred D. Davis, 1989, 1993; Viswanath Venkatesh & Davis, 2000) was used along with the VARK learning styles tool to measure learner preferences (learning styles) as visual, auditory, read/write, and kinaesthetic. A number of researchers (Bell, Koch, & Green, 2014; Drago & Wagner, 2004; Lau, Yuen, & Chan, 2015) have advocated for the validity of VARK as a learner preference measuring instrument.

The rationale in this study is- design students, who are mostly visual and kinaesthetic learner will prefer to use an information delivery method that delivers a higher level of tactility and visual cues, therefore, it will decrease cognitive load and increase intrinsic motivation to construct a meaning resulting effective learning.

Learner's preference over learning style and the use of modalities as a mean to learn have influence over the learning effectiveness. It also influences the way one constructs meaning, represents experience, relates to reflections and effectively applies acquired knowledge. The primary hypothesis of this study is that learners' preference has a correlation with the acceptance of certain means of information delivery method or technique, therefore it affects the learning effectiveness through lowering cognitive load and intrinsic motivation that commonly visible in constructive learning and teaching methods (Figure 1).

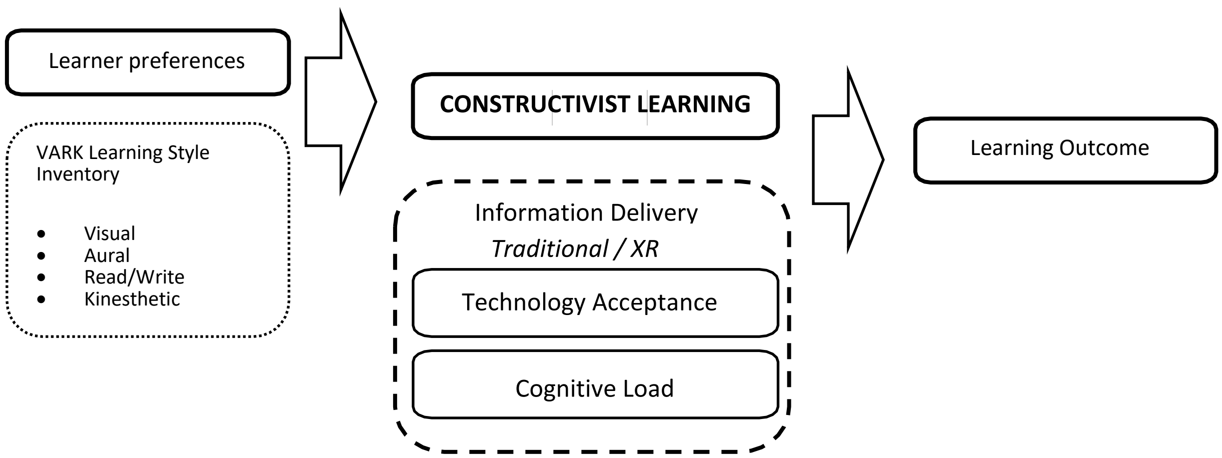


FIGURE 1. THE EFFECT OF LEARNER PREFERENCES ON LEARNING OUTCOME IN CONSTRUCTIVIST LEARNING APPROACH

Current State of Design Education and its Realignment

Concerns regarding design education and its alignment with today's digital age, generation Z students' learning preference, and fast-changing needs of the industry are not new. In one form or another, similar issues have emerged in the early restructuring efforts of 1960s experimental college by John Dewey, Alfred Whitehead, Jean Piaget, Benjamin Bloom and more recently David Kolb (Salama, 2006). Fisher (2000) mentioned, "Studio culture pedagogy originates, in part, from 18th century and 19th century French rationalism, which held that through the analysis of precedent and the application of reason, we could arrive at a consensus about the truth in a given situation". Originated from the Ecole des Beaux-Arts, this approach of design learning and teaching was adopted by the Western schools of architecture and then spread around the world. It was emerged around the seventeenth century in France to represent the authoritative needs at that time and lasted for over two hundred years as the only model for design education. Due to the change of the value system caused by technological development and industrial revolution, an alternative approach emerged at the end of the nineteenth century in Germany called the Bauhaus model. Most of the design schools around the world are highly influenced by Beaux-Arts and Bauhaus models and still follow the same principles. These approaches of design pedagogy created a distance from the real world because of the lake of opportunities it provides to learn from the 'richness and depth of human experience' (A. Salama & Wilkinson, 2007).

In recent decades, technology has faced several major shifts which also influenced the lifestyle and learning preferences of design students of today's digital age. The most recent shift from the Information Age to the Experience Age brought a major challenge for design educators (Hu-Au & Lee, 2017; Wadhera, 2016). Since the act of design is an individualistic, creative and diverse domain grounded on non-linear thinking and problem-solving process where rationale emerges from individual designer's level of experience, reflections and perceptions. Therefore, an exploratory, constructive learning environment can improve the motivation, attention and overall learning outcome (Clark, D. 2006 in Piovesan, Passerino, & Pereira, 2012). Virtual, Immersive and augmented learning environments provide unique contextual role-playing and reasoning experience where early design students learn the essential skills as creative thinking, empathy, conceptual understanding, system thinking and such through learning by doing. This also provides design students of this digital age necessary active engagement (Capps & Crawford, 2013) and relevance of the learning material to their professional life (Gee, 2009).

Extended Reality as Constructivist Learning Environment for Design Education:

Extended Reality (XR) is the umbrella platform that encompasses phenomena from Virtual Reality, Augmented Reality and Mixed Reality. By definition, it incorporates real and virtual environment and relevant interactions between human and computers. The goal is to offer feedback based experiences mainly involving the senses of existence, confirming cognition and interaction with contextual geometry and design elements. Digital modalities can facilitate human memory and learning by refining mental models, adding interpretations and providing experience by augmenting the real world (Perkins, 1992). Virtual, Augmented and Mixed Reality technologies have proven its potential by providing a constructivist learning environment that creates a natural and social interactive platform to mediate interaction with the contents (Dede, 1995).

In constructivist learning theory, learners construct knowledge and meaning from experience, active participation and performing tasks in the context which allow learners to contextualize the process of constructing knowledge instead of being a passive learner (Salomon & Perkins, 1998). With various methods constructivist learning allows students to get engaged based on his or her specific character, talent and preference; therefore, it is considered as a useful method to disseminate information in design studios (Jones & Brader-Araje, 2002; Naylor & Keogh, 1999; Rovai, 2004; Soygenis, 2009).

Learners make a tentative interpretation of experience, elaborate and test those interpretations based on their reflections until a mental structure is formed and satisfactory structure emerges. The learning environment and information delivery method need to be supportive of the development of this inherent constructivist character. By facilitating human memory and intelligence extended reality based digital modalities create constructivist learning platform and offer multiple interpretations, mental models and experience of built environment (Dede, Salzman, & Loftin., 1996; Perkins, 1991). Constructivist digital studio incorporates innovative approaches (Gül et al., 2007) as experience-based “new ways of designing” (Kvan & Jia, 2005) by integrating the Extended Reality (XR) technology and design thinking (Gül, Gu, & Williams, 2008; Kvan & Jia, 2005).

Constructivist Learning Environment that Promotes Experience using Extended Reality:

As discussed in the previous section- since Bauhaus experiments of the 1930s, alternative approaches for design education received increasing attention among design researchers (Gül et al., 2008) as “Reflective Practitioner” philosophy Donald Schon (1987), “Problem-Based Learning” by Donald Wood (1994). By integrating diversity in knowledge, skills, culture and problem-solving ability to satisfy ‘real-world’ needs, Woods (1994) formed experiential learning approach that essentially is based on reflection. In traditional model of education, instructors deliver information to the students following ‘one size fits all’ method that appears to be outdated and increasingly unsuccessful (Hu-Au & Lee, 2018; Wadhera, 2016). This is due to the shift of Industrial Revolution model of education to an Information Age model where information accumulation was in highest priority and now in the Experience Age where information is constructed through experience and ‘on demand’. It is evident in generation Z design students’ lifestyle where the ubiquity of interconnected mobile devices, cloud-based large data, gaming and social networking application, various machine learning and artificial intelligence support have altered the expectation and understanding of information sharing and experiencing new points of view.

Use of emerging technologies and new information is the fundamental approach of the constructivist learning approach of design. Constructivism demonstrates methods of constructing his/her own understanding and knowledge about the world around them by experiencing elements and reflecting on those experiences (Mahoney, 2004). Using an active and interactive learning process knowledge is obtained and synthesized by active (re)constructions of learner’s mental frameworks (Abbott & Ryan, 1999; Brown, Donovan, & Pellegrino., 2000).

Extended Reality has tremendous potential to be used as an information delivery tool for any constructivist learning environment since it encompasses the characteristics of VR, AR and MR. Virtual Reality and Augmented Reality technologies are widely being used in design education and industry but mostly for presentation purposes. VR is considered as an immersive computer-generated and simulated three-dimensional environment while AR superimposes virtual geometry over the physical environment.

Extended Reality is much flexible and completely immerses its user inside a computer-generated environment where the user may or may not relate to the physical environment, but can interact, receive feedback, forwarded to secondary sources for further information and such. Like AR interface XR (Extended Reality) offers tangible interaction (Ishii, 2007) which might be useful to the kinesthetic learner while visual learner benefits from VR. A void exists in knowledge about these several decades old technologies' effect on human factors (Huang, Alem, & Livingston, 2012), acceptance of technology (Fred D. Davis, 1993; Dishaw & Strong, 1999; Igbaria, 1993) and measured cognitive load (Mohamed-Ahmed, Bonnardel, Côté, & Tremblay, 2013) that potentially contributes to the intrinsic motivation to learn and construct new knowledge resulting effective learning in design studios. Therefore, a comprehensive understanding of user experience factors in this virtual and augmented environment is essential to verify its usability as a pedagogical tool for constructivist design studio. At the same time this understanding will help with experimenting, developing and introducing such new technologies into mainstream design pedagogy to support generation Z's learning style and preferences.

User Preferences on Design Learning

Most of the discussions, instructions and explorations in the design studio utilize digital modalities of various kind. Individuals (re)act differently with different digital interfaces because of their background, exposure, aptitude with the technology in use as well as the intrinsic quality of the tools they are using. One of the goals of this study is to explore user preference of digital interface for learning design ideas. Constructivist learning theory highlights the human-centered approach. Most researches in design education using digital media have focused on the use, development and technical aspect of it. A few studies exist on the human center approach (Gabbard & Swan II, 2008) and experience-oriented aspect of design learning approach. It is essential to understand the relation between user preference and system's characteristics because in extended reality technology both physical and virtual objects create the environment in combination (Grier et al., 2012).

It is crucial for designers to effectively communicate complex design solutions which require intellectual comprehension of a given design problem and ability to synthesize, manipulate and construct a mental image of the solution beforehand (Isham, 1997). Since the act of design is highly subjective so as the designer's cognitive ability, thinking process, innate skills, intelligence and preferred learning method. Gardner (2011) developed multiple intelligence theory and identified seven types of intelligence among designer as logical, kinesthetic, spatial, interpersonal, intrapersonal, verbal, and musical. He mentioned individual success in any specific sector is dependent on the selection of the appropriate and preferred method of education, in other word information delivery method that foster this intelligence. According to Thurstone (1938), factors as associative memory, perceptual speed, reasoning, spatial visualization, word fluency and verbal comprehension work in combination to define intelligence. Among these, mental rotation, spatial visualization, and spatial perception characterize one's ability for spatial perception.

Constructivist learning and teaching emphasize on learner-oriented teaching method that does not follow 'one size fit all' approach. Therefore, it is important to understand the idea of learning styles because each individual has a preferred method of learning that suits them the most. This study focuses on identifying individual learner's preference of instructional modality for delivering information in design studio (i.e., through the Traditional or XR interface).

Learner Preferences in Design Education

Learning styles or preferences in design describes the different patterns of how designers learn and solve problems (James & Gardner, 1995). A number of classifications developed by researchers on how individuals learn; for example, Keefe (1979, p. 2) defined it as "cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". Personality learning, information processing, social learning, and multidimensional instructional learning are considered as four major learning theories which were identified by Curry (1983). The common denominators among all these theoretical frameworks are the personality, information processing and interaction with the environment (Kolb, 1984). While describing learning, Gardner (1983) mentioned a number of dimensions of learning as interpersonal, intrapersonal, visual-spatial, bodily-kinesthetic, linguistic, and logical. This study attempted to understand design students' learning styles by identifying their preference for different types of information delivery methods (traditional and XR based) and perceived efficiency of that interface for effective learning in design studio.

Through observation and exploration of design students' learning preferences design educators tried to identify a connection between teaching and learning in the design studio (Demirbaş & Demirkan, 2003; Kvan & Jia, 2005; Newland, Powell, & Creed, 1987) as well as cognitive styles (Newman, 1981). Generally learning preferences varies between learners from different disciplines of education (Felder, 1988). Students from certain disciplines may show some similarities in learning preferences due to shared interests and comparable aptitude (Felder, 1988; Lujan & DiCarlo, 2006). Design education is heavily dependent on visuals, survey of physical environment, demonstrative activities and such which dictate certain learning preferences. Successful problem solving rely on (self) reflection (Schon, 1987) where designers revisit and reflect on design thinking based on their previous experience and exposure (Newland et al., 1987). Designers acquire these experiences and exposures over time; however, constructing meaning from observation require different level of cognitive ability. Therefore, information and instruction delivery methods that reduce cognitive load and promote motivation and acceptance among learners are likely to positively affect meaningful learning.

Constructivist Learning, Experience, Motivation and Acceptance:

Alternative approaches for design pedagogy received more attention among design educators since the Bauhaus experiments of the 1930s (Gül et al., 2008). In constructivist learning, emerging technologies and new information play a fundamental role. Reflection is one of the most valuable instruments of a designer which is essentially based on diversity in knowledge, skills, culture and problem-solving ability to satisfy ‘real-world’ needs. Due to the differences in cognitive ability successful mental construct occurs when information is delivered using preferred method that motivates the learner. Personal determination to accomplish something is generally considered as motivation which can be intrinsic or extrinsic. Accomplishing a job for one’s own satisfaction is intrinsic motivation while finishing a task without any determination and only it means to an end approach is defined as extrinsic motivation (Amabile & Gryskiewicz, 1989). In the context of design learning, when intrinsic motivation is less creativity, output and learning effectiveness decreases (Casakin & Kreitler, 2009; Collins & Amabile, 1999; Kreitler & Casakin, 2009).

Within TAM (technology acceptance model), perceived usefulness (PU) defines "the degree to which a person believes that using a particular system would enhance his or her quality and performance" while perceived ease of use (PEU) defines "the degree to which a person believes that using a particular system would be free from effort" and considered as an important determinant for user acceptance (Fred D. Davis, 1989). Intrinsic motivation for using technology and mechanism can be captured and constructed by utilizing the technology acceptance model (TAM) (Fred D. Davis, 1989, 1993; Viswanath Venkatesh & Davis, 2000). Intrinsic motivation to learn and effectively use any instruction or delivered information is related to perceived ease of use as considered by its user (Viswanath Venkatesh, 2000). These two perceived variables influence learner’s attitudes toward effectively using technology and the behavioral intention to use (BIU) technology for future activities. If learner is motivated to use the technology that promotes constructivist learning through active participation and interaction then effective learning can occur. Technology acceptance is related to perceived ease of use (PU) and perceived ease of use is affected by intrinsic motivation; therefore intrinsic motivation is very likely to be affected by technology acceptance (Figure 2).

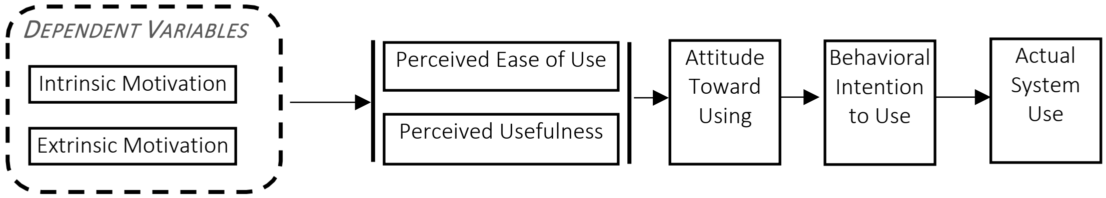


Figure 2: Motivation on the technology acceptance (TAM).

Perceived ease of use demonstrates the ability to maneuver a wide range of computer applications for various purposes (Schiller, 2003). In the context of this study, perceived ease of use reflects design students' degree of expectation over the information delivery system be free from effort and require less cognitive load (Fred D. Davis, 1989). Perceived ease of use also refers to the intrinsic motivation which enhances learning outcome. This study examined whether perceived ease of use is related to learning using this connection. In the traditional method of instruction in design studio does not offer enough opportunity for kinesthetic learners which can be optimized using the tangibility of digital user interfaces in the context of the specific built environment. According to Gee (2009), students struggle to find relevance to their real-life activity when information is delivered out of context. In the traditional method of information delivery creating a scenario of realistic context is difficult and require either higher level if cognitive involvement or experience form learners. Virtual environments can be considered as an extension of traditional design pedagogy to motivate visual, kinesthetic or aural learners. Moreover, generation Z learners need to develop some crucial skills as creativity, empathy, integrated design and system thinking, abstract reasoning which are difficult to teach (Smith and Hu, 2013) and to some extent is ignored in the traditional method of design learning and teaching (Hu-Au & Lee, 2018). Within the framework of constructivist design pedagogy, this study investigated learners' preference over the use of traditional and XR based information delivery method. Learner's preference affects motivation (Anasol, Ferreyra-Olivares, & Alejandra, 2013) to learn and actively participate. Therefore, preference of instructional method will affect effective learning (figure 3).

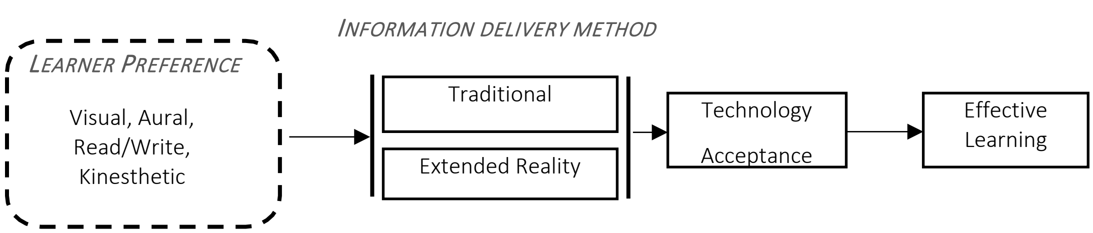


Figure 3: Effect of learner preference on information delivery methods

Identifying Learning Styles: VARK Learning Modalities

The VARK (visual, aural, reading and writing and kinesthetic) measures learning information and preference through sensory modalities (Fleming & Mills, 1992). Many studies have used VARK inventories (Bell et al., 2014; Drago & Wagner, 2004; Lau, et al., 2015; Lujan & DiCarlo, 2006; Marcy, 2001; Wehrwein, Lujan, DiCarlo, 2007). Fleming & Mills (1992) suggested four perceptive modalities that indicate learners' experience and constructs a measurable learning preference for efficiently attaining and recalling information. Researchers have used the VARK Learning style inventory because of its simplicity and reliability. Leite, Svinicki, and Shi (2010) conducted factor analysis and evaluated VARK inventory which confirms its validity as the reliability coefficients in their test appeared to be satisfactory.

Visual learners learn best by seeing various pictorial and graphical contents as symbols, charts, diagrams, illustrations, videos and such instead of words or listening. Aural (or auditory) learners acquire information most efficiently by hearing from discussions, lectures and conversations. Reading and writing learners prefer to take the information provided through words and texts. Their preferred method of obtaining information is through textbooks, taking notes, readings, and printed handouts. Kinesthetic (or tactile) learners prefer to gather information by touching and doing, through hands-on experience and trial and error. Some learners do not have any specific preference and learn efficiently using multiple of these modalities. These type of learners are referred as multimodal learner.

Methods

A quantitative research method was adopted in this study using analysis of subjective survey data. A small number of interior design students participated in the study. Their responses were examined to find answers to the research questions. Information delivery method in the design studio was considered as the independent variable which had two levels: Traditional and Extended Reality (XR) based instructions. Learner preference was included as a moderating variable while technology acceptance model was used as dependent variable.

Following are the questions this research seeks the answer of:

How do Information delivery Methods (Traditional, & XR) and learner preference affect the learning outcome?

a. How technology acceptance is affected by information delivery method?
b. How learner preference interrelate with the information delivery methods that affect overall learning outcome?

Hypotheses for questions a & b-

H1: The type of information delivery methods used in design pedagogy affects the perceived ease of use (PEU) of the information delivered.

H2: The type of information delivery method used in learning process affects the perceived usefulness (PU) of the information delivered.

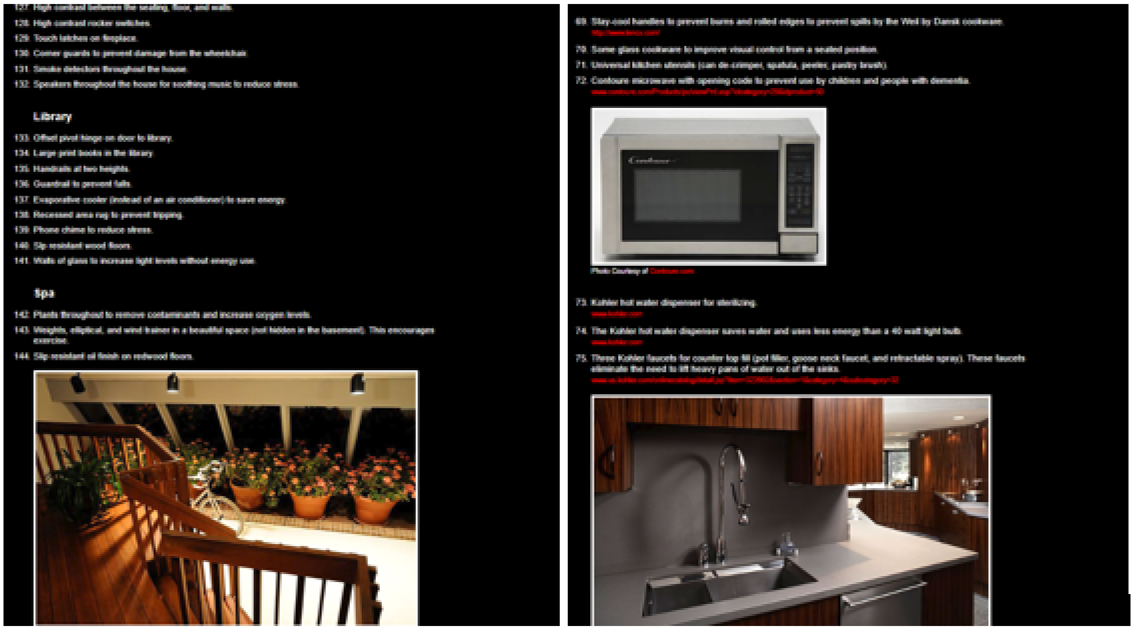
H3: The learning preference of the user assumes the Perceived Ease of Use of the information delivery modality.

H4: The learning preference moderates the Perceived Usefulness of the information delivery modality.

In this study universal design strategies and its application in residential settings were used as the information delivered to a small number of interior design studio students. Universal design focuses on manipulating and designing a built environment for not only accessibility but also to accommodate greater extent of users regardless of individuality, culture and ability. Two interfaces were used for information delivery: traditional text and image-based and XR based interface. Thirty-two volunteers participated in the study. After the institutional review board approval, purposeful sampling was used to select the participants who are design students (juniors, seniors and graduate) at a Midwestern university in the US. The participants were then randomly assigned to either of the two interfaces for delivering information. Following is demographic information of all participants.

Table 1: Demographics in the Two Groups

	Gender		Age			Academic		
	M	F	18-25	30-35	35+	Senior	Junior	Graduate
Traditional	1	15	14	2	0	10	2	4
XR	2	14	14	1	1	9	3	4



127. High contrast between the sealing, floor, and walls.
128. High contrast rocker switches.
129. Touch latches on fireplace.
130. Corner guards to prevent damage from the wheelchair.
131. Smoke detectors throughout the house.
132. Speakers throughout the house for soothing music to reduce stress.

Library

133. Offset pivot hinge on door to library.
134. Large print books in the library.
135. Handrails at two heights.
136. Guardrail to prevent falls.
137. Evaporative cooler (instead of an air conditioner) to save energy.
138. Recessed area rug to prevent tripping.
139. Phone chime to reduce stress.
140. Slip resistant wood floors.
141. Walls of glass to increase light levels without energy use.

Spa

142. Plants throughout to remove contaminants and increase oxygen levels.
143. Weights, elliptical, and wind trainer in a beautiful space (not hidden in the basement). This encourages exercise.
144. Slip resistant oil finish on redwood floors.

69. Stay-cool handles to prevent burns and rolled edges to prevent spills by the Weil by Dansk cookware.
70. Some glass cookware to improve visual control from a seated position.
71. kitchen utensils (can de-crimper, spatula, peeler, pastry brush).
72. Contoure microwave with opening code to prevent use by children and people with dementia.

Photo Courtesy of

73. Kohler hot water dispenser for sterilizing.
www.kohler.com
74. The Kohler hot water dispenser saves water and uses less energy than a 40 watt light bulb.
www.kohler.com
75. Three Kohler faucets for counter top fill (pot filler, goose neck faucet, and retractable spray). These faucets eliminate the need to lift heavy pans of water out of the sinks.

FIGURE 4: TRADITIONAL METHOD OF INFORMATION DELIVERY

Information regarding applications of universal design was given to the participants using traditional text and image-based method using pdf file format on computer monitor. Participants were asked to read the document as provided material given by the studio instructor after lecture.

Secondly, in the Extended Reality participants used a Virtual Reality device (Oculus Rift®) attached to a computer. A three dimensional model of the same case study residence was prepared using Autodesk Revit and Unity 3D game engine. Later hotspot markers were applied to all key spatial and design attributes where universal design aspects were implemented. Using Oculus Rift head-mounted display device and controllers participants were able to move through the virtual environment (different spaces within the residence), interact with various components as opening doors, windows, kitchen cabinet doors, turning on and off lights and such to evaluate the accessibility and ergonomics, etc. At the same time gazing at or using controller button hotspots could be activated which allowed participant to see detailed description of the universal design attributes applied to that specific design features and fixture. Participants also could select from an array of different materials as carpet texture or furniture selections to experiment with multiple aspects of universal design in the context.

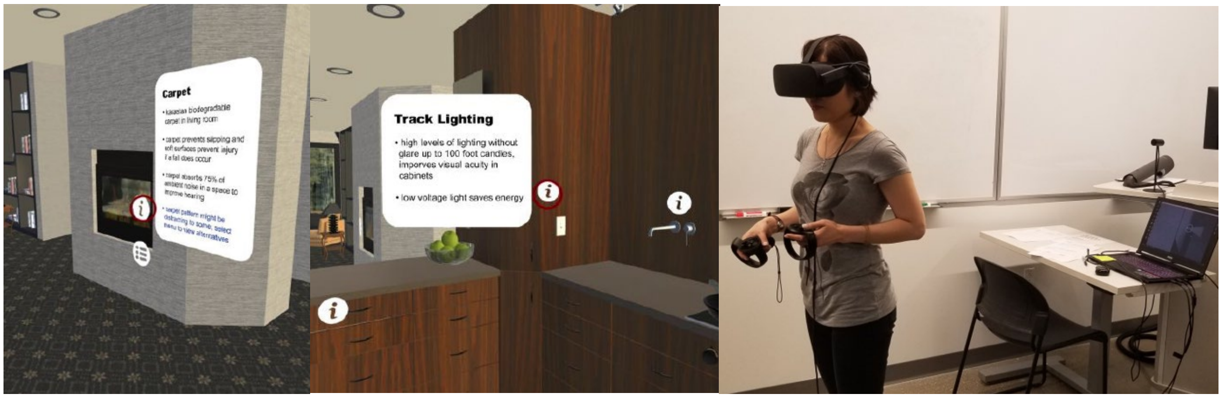


Figure 5: Extended Reality based information delivery

All participants from the two group were given the VARK learning styles inventory (pre-test) to identify their learning style and the technology acceptance model (TAM) questionnaires (post-test) to better understand participants' perception of these two information delivery methods and how it affects their learning preferences. The task in this experiment was to review and explore universal design strategies implemented in a residential case study through computer-generated Extended Reality environment and text and image-based document (Figure 4 and 5). To identify cognitive load associated with each of the information delivery methods all participants also answered the NASA task load index (TLX) questionnaire. NASA TLX can be downloaded and used for non-commercial use. The online version of this tool was used in this study and was administrated after the task was performed to obtain participants' perceived overall scores for cognitive engagement and load.

In short, this study expected that the learner preferences may affect and have a direct correlation with the information delivery methods in design studios which may affect learning performance.

Reliability and Validity

This study adopted the technology acceptance model (TAM) questionnaire from a recognized TAM scale to measure the subjective perceptions of technology use for delivering information in the design studio. A number of previous researches have validated TAM (Davis, 1989, 1993; Davis, Bagozzi, & Warshaw, 1989; Ong & Lai, 2006; Venkatesh & Davis, 2000; Venkatesh & Speier, 2000).

To measure learner preferences for visual, auditory, read/write, and kinesthetic learning styles the VARK Questionnaire for learning styles were used. The validity of the VARK as a learner preference identifier has been confirmed by many researchers (Bell et al., 2014; Drago &

Wagner, 2004; Karim, 2014; Lau et al., 2015; Leite et al., 2010; Marcy, 2001). After obtaining permission from the author online version of VARK questionnaire was used without alteration, therefore checking the reliability or validity was not essential.

Analysis and Discussion

Several studies conducted before have claimed that intrinsic motivation can directly impact learning. A high degree of Perceived Ease of Use (PEU) positively encourages learners' intrinsic motivation of an information delivery modality. Perceived Ease of Use, Perceived Usefulness (PU) and Behavioral Intention to Use (BIU) are some factors emphasized in the Technology Acceptance Model (TAM). Davis, Bagozzi, and Warshaw (1989) introduced the technology acceptance model (TAM) to address how users of commercial technologies accept and use the technologies. Recently, TAM has been used by educational researchers into the same settings. To identify the effects of learner preference on the two information delivery methods and relationship between them, Perceived Ease of Use (PEU), Perceived Usefulness (PU), and Behavioral Intention to Use (BIU) were compared between traditional and XR instructional method for two specific learning styles (kinaesthetic and visual).

Multiple statistical tests were conducted to examine the hypotheses. ANOVA (One-way analysis of variance) was executed to compare the dependent variables (PU, PEU and BIU) among two instructional modality types. Interaction between instructional methods and learner preference was described by performing a two-way ANOVA. The relationship between PU and PEU was measured using bivariate correlation coefficients (Pearson's r).

Comparison of the Dependent Variables (PU, PEU and BIU) between the two information delivery modalities

To analyze the difference between the two information delivery modalities (Traditional and XR based) and the dependent variables (Perceived Usefulness and Perceived Ease of Use) a one-way ANOVA was performed. See table 2 for descriptive statistics of PU, PEU and BIU by information delivery modalities. Table 3 shows ANOVA results for PEU, PU and BIU.

Table 2: Descriptive Statistics for the Traditional and Extended Reality based information delivery method

Dependent Variable	Independent Variable	Mean	SD
Perceived Ease of Use (PEU)	Traditional	4.093	0.663
	XR	5.282	0.901
Perceived Usefulness (PU)	Traditional	3.219	0.522
	XR	4.921	0.859
Behavioral Intention to Use (BIU)	Traditional	3.888	0.900
	XR	5.195	0.935

Note: N = 16 *(In each group)*

Table 3: ANOVA Summary Table for Information delivery modalities

Dependent Variable	Source	SS	df	MS	F	p
Perceived Ease of Use(PEU)	Between Groups	11.305	1	11.305	18.045	.001
	Within Groups	18.794	30	0.624		
	Total	30.099	31			
Perceived Usefulness (PU)	Between Groups	8	1	8	15.801	.004
	Within Groups	15.179	30	0.505		
	Total	23.179	31			
Behavioral Intention to Use (BIU)	Between Groups	13.676	1	13.676	16.221	.003
	Within Groups	25.292	30	0.843		
	Total	38.969	31			

There is a significant difference between the two method of information delivery modalities for all three dependent variables: PEU, $F(1,30) = 18.04$, $p = .001$); PU, $F(1,30) = 15.80$, $p = .004$); and BIU, $F(1,30) = 16.22$, $p = .003$). Means of all three dependent variables were significantly higher in the XR interface type, PEU: $M = 5.28$, $SD = 0.90$; PU: $M = 4.92$, $SD = 0.85$; and BIU: $M = 5.19$ $SD = 0.93$, compared to the Traditional interface type, PEU: $M = 4.09$, $SD = 0.66$; PU: $M = 3.21$, $SD = 0.52$; and BIU: $M = 3.88$, $SD = 0.90$.

Comparison of the Dependent Variables between Information delivery modality and Learner preference

Interactions among information delivery modality (independent variable) and learner preferences (moderator variable) on the technology acceptance measured through PU, PEU and BIU (dependent variables) was examined using a two-way ANOVA for each of the dependent variables. The effect of information delivery methods and learning styles on perceived usefulness was significant ($p < .005$). Comparisons between pairs of means (Table 5) shows that the mean value of perceived usefulness is considerably higher in the Extended Reality based information delivery method than the traditional mode of information delivery for the visual and kinaesthetic learner type.

Table 4: Descriptive Statistics for PU (Perceived Usefulness)

Information Delivery Method	Learner Preference	Mean	Std. Deviation	n
	Visual	3.8	0.758	5
	Aural	3.84	0.288	3
Traditional	Read/Write	4.51	.	1
	Kinaesthetic	4.05	0.480	5
	Multimodal	3.75	0.353	2
	Visual	4.62	1.198	4
	Aural	5.25	0.712	2
XR	Read/Write	4.5	0.353	2
	Kinaesthetic	5.29	0.827	6
	Multimodal	4.75	0.314	2

Table 5: Differences in Perceived Usefulness between Traditional and Extended Reality based information delivery methods by Learner preference

Learner Preference	Mean Difference	SE	*p*
Visual	-0.82	.398	.000
Aural	-1.41	.443	.389
Read/Write	0.01	.934	.312
Kinaesthetic	-1.24	.367	.004
Multimodal	-1	.451	.001

$p < .01$

To measure correlation among TAM variables *Pearson's r* were considered which suggest a positive correlation between perceived usefulness (PU) and perceived ease of use (PEU) on behavioral intention to use (BIU).

Table 6: Correlations among perceived usefulness, perceived ease of use and intention to use of information delivery modalities

		(PU)	(BIU)
Behavioral Intention to Use (BIU)	Pearson's r	.819#	
	Significance	.002	
Perceived Ease of Use (PEU)	Pearson's r	.520#	.684#
	Significance	.002	.000

Note: N = 32 # $p < .001$

Cognitive load required to perform tasks with traditional and Extended Reality instruction method was compared using independent sample *t*-test. The difference appeared significant *p = 0.00546* (table 7) suggesting cognitive load in Extended Reality based information delivery method was lower than the traditional mode.

Table 7: Overall Cognitive Load Measurement

	Cognitive Load (NASA TLX)		
Information Delivery Method	Mean	SD	n
Traditional	54.78	5.27	16
XR	36.76	3.97	16

df:28, P(T<=t) two-tail= 0.00546

Findings

This study investigated effects of technology acceptance on information delivery methods and relationship between learner preference and mode of information delivery to examine which instructional and information delivery method, using technology creates a constructivist learning environment for design students resulting effective learning.

Four hypotheses were tested as: i) information delivery methods has effect on perceived ease of use of the information delivered, ii) perceived usefulness of delivered information is affected by its method of delivery, iii) learning preference dictates the perceived ease of use of information delivery method and iv) learner preference also dictates the intention to use of information delivery modalities. Difference between traditional and Extended Reality based information delivery was significant for its perceived usefulness, behavioral intention to use and perceived ease of use. Participant design students perceived in this study that Extended Reality based information delivery were more useful than traditional text and image-based mode. Value of perceived usefulness and perceived ease of use were significantly higher in information delivered through Extended Reality for visual and kinaesthetic learners. Therefore, null hypothesis for hypothesis i-iv were rejected.

Researchers have used Technology Acceptance Model (TAM) in numerous occasions to identify motivation (intrinsic and extrinsic) to use and effectiveness of technology usage for performing a task (Fred D. Davis, 1989, 1993; V Venkatesh & Speier, 2000). Learners' perceived ease of use regarding a method assisted by technology to deliver information (instructions) affects intrinsic motivation (Viswanath Venkatesh, 2000); therefore, it encourages active use of information and enhances the learning process.

Conclusions

This study focused on identifying the relationship between users' perception of information delivery methods that promote a constructivist approach of learning and teaching in design studios. Therefore the research investigated association between user preference and effectiveness of the two modes of information delivery. Extended Reality based information delivery place the leaner in a three-dimensional virtual environment representing realistic representation of the world and its context. Users can interact with design elements and construct in-depth meaning while associating provided new information with existing knowledge and reflect in relation to the context. This also reduced required cognitive load to process and contextualize new information and encourage intrinsic motivation to actively learn compared to the traditional mode of information delivery that relies on text and images.

Design students are predominantly visual and kinaesthetic learners. Design education is generally based on various visuals and activities with physical elements. Individuals have different learning preferences which affects their learning effectiveness. Outcomes of this study suggest XR based information delivery method was easier to use and more effective than traditional means of teaching design ideas and principles. Selection of different types of instructional technology and methods affect how effectively learners construct meaning and use the provided information. This insight can be useful for design researcher and educator in developing a learner-centered constructivist design pedagogy.

Limitations

This study has several limitations. Besides relatively lower number all of the participants were from same geographical region and from one Midwestern University studying interior design. The study focused on only learning universal design's concept and its application as the information delivered. Even though the participants were randomly assigned to two groups, unequal distribution of gender and academic status may have contributed to results of the study. This is because some senior and graduate students are more experienced and have exposure to the information derived from other source.

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Examining Estonian Schoolteachers' Attitudes Towards the Use of Applied Science Knowledge Within Craft Education

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Abstract

This article examines the possibility of supporting craft education by incorporating knowledge students have gained via science lessons: such knowledge largely refers to the mathematics and physics taught in Estonian comprehensive schools. Results were gleaned from interviews with craft teachers in Estonia, in order to establish their attitudes to the idea of integrating science with craft. Their ideas are presented here, along with a comparison of their understanding of the pedagogy. The results of the study address the following research questions:

1. *Do teachers consider the National Curricula supportive, in terms of integrating science knowledge in order to support craft education?*
2. *How do teachers recognise knowledge of science during craft processes?*
3. *Are teachers aware when science is integrated into their teaching?*
4. *What do teachers consider the benefits of such integration?*

The research demonstrated the pedagogy of integrating knowledge of science with craft as a novel idea, based on a process of merging the two knowledge models. The result of this process is a development of a new area of knowledge that can both enable students' understanding and their design and fashioning processes. Moreover, it relates to real-world phenomena and thus helps students with their ideation. Such new knowledge is achievable when knowledge from one of the fields is used in the other field, whether science or craft. The integration of science with general craft education is dependent upon both the National Curricula and a teacher's method of teaching.

Keywords

integration, science knowledge, craft education, pedagogy, Estonia

Introduction

The ability to transfer knowledge and skills gained in one subject to lessons of another subject or to real-life situations is an important ability within modern society. The term *transferring knowledge* basically means to learn something in one context and apply it in another (Fogarty, 1991). Thus, the skill of knowledge transfer is the foundation of knowledge integration. Due to a lack of integration of theoretical knowledge with practical life skills, the Estonian government has set out a new national curriculum for general education (Government of the Republic, 2014), with an emphasis on integration.

Today, the Estonian craft subjects have a technological focus, with the aim being to enable students to acquire the mentality, ideals and values inherent in modern society. They learn to understand options in problem-solving when creating new products and locating and utilising sustainable manufacturing processes. Students are taught to refer to various sources of information in their studies and analyse phenomena and situations. There is a focus on creative thinking and hands-on activities. Students are trained in the process of ideation and are taught to plan and prepare objects or products, in addition to presenting them (Ainevaldkond Tehnoloogia, 2011).

We can perhaps say that science is an element in craft. Science explains how technology works and technology is utilised in craft. Undertaking handicraft therefore provides students with opportunities to learn about and utilise various technologies, via hands-on. Part of the knowledge gained from practicing or learning craft can be called applied science (Thorsteinsson, 2002).

Applied sciences, according to Collins online dictionary (2019) is science that is put to practical use. It is the application of existing scientific knowledge to practical applications, like technology or inventions. Within natural science, disciplines that are basic science, also called pure science, develop basic information to predict and perhaps explain and understand phenomena in the natural world.

Various subjects, such as mathematics, chemistry, physics and history, are naturally linked with craft or are adopted within craft education. Although there has been lots of discussion about integrating the sciences within different subject areas in comprehensive school education, science as a subject has remained rather isolated and has not changed over the years. This may be the reason why many students are unable to understand the world around them via knowledge of science they have gained via general education, which in turn might de-motivate students in learning scientific knowledge.

If knowledge of science is not applied in craft lessons, this negatively affects students' attitudes towards solving various problems within craft education: building upon scientific knowledge aids the development of problem-solving skills. In terms of craft education, this concerns knowledge of various materials and the use of technology in making solutions. The best way to understand different technological processes and become aware of their validity within the world is to utilise them during applied craft work.

The article firstly introduces the historical background of Scandinavian craft education and the initiators' interest in *science,* and then the authors examine literature pertaining to Estonian craft education at the present time. The authors discuss the Estonian national curricula, outline the aims of The Ministry of Education in terms of cross-curricular school activities and present the results of their survey, in examining the status of students. Finally, they explain the research methodology, discuss the results and draw their conclusions.

Craft Education within Scandinavian Schools

Pedagogically-based craft education, according to Olafsson and Thorsteinsson (2009), was established in Scandinavia in the 18th century and was a school-based system of formative education, using the term *Sloyd*. *Sloyd* originally meant 'handy or skilful' and refers to the making of crafts (Chessin, 2007). However, the definition of Sloyd in relation to education refers to the discussion amongst philosophers of those times regarding the value of craft within general education (Borg, 2008). The purpose of Sloyd was to use craft as an instrument within public education with which to build the character of children, encouraging moral behaviour, greater intelligence and industriousness (Thorarinsson, 1891).

Sloyd was initially considered a school activity based on craft and was intended for personal development. The aims were pedagogical, rather than teaching students to make objects for their daily lives (Thorarinsson, 1891, p.7). Philosophers such as Comenius, Locke, Rousseau, Franke, Pestalozzi and Fröbel all underlined the significance of physical training and craft within general education. They influenced those educators who established the Sloyd movement in Scandinavia (Olafsson & Thorsteinsson, 2009).

The Finnish scholar Dr Cygnaeus (1810-1888) founded public schools in Finland in 1866 (Kananoja, 1989). He developed Pestalozzi's and Fröbel's ideas further and established craft as an obligatory subject which aimed to improve public education in Finland (Thorarinsson, 1891; Thorbjornsson, 2006). Handicraft training became a significant aspect of the upbringing of all children via general education. It supported an understanding between classes in society and included physical exercise (Bennett, 1937). Finland's Uno Cygnaeus and Sweden's Otto Salomon were major leaders in the development of a systematic Sloyd model for school education and they emphasised the usefulness of constructing objects through formal educational methodology (Kantola, Nikkanen, Kari & Kananoja, 1999). Sloyd had a notable impact on the early development of manual training, manual arts, industrial education and technical education in many countries (Bennet, 1926).

Science-Sloyd

Many of the initiators of pedagogical craft had an interest in science and gave their students tasks involving the fashioning of physical devices. The nobleman Locke (1632-1704) was interested in polishing lenses, while Francke (1663-1727) asked his students to make optical equipment and taught them how to use a lathe to polish glass they used in binoculars, for enlarging glass, microscopes and to examine perspective. Rousseau (1712-1778) wrote in his book of Emil: '*We should make physical equipment ourselves*' (Dansk Slöjdlærerforening, 1938: p.38).

In his book *About Goals and Resources for the Higher School Education*, Professor Kromann (1886) underlined the pedagogical value of students utilising physics in order to gain true scientific experience via craft. Kromann wrote: '*Instead of seeing the school's collection of physical devices at a distance without daring to investigate them, the student himself should make the most important equipment and thereby make sure he has really understood the principles of physics* (Kromann, 1886, p.38).

In 1888, a college teacher, Deputy Julius Petersen of Herlufsholm in Denmark, was involved in the assignment of connecting craft education with natural science, saying: '*Can you raise student's interest in the disciples of science - and it is not difficult - then it will be easy to give them the pleasure of making some devices by themselves, and, conversely, the one who works handy with physical equipment will not only become familiar with the principles, but, in reality, also acquire better insight into the effects of natural forces'* (Dansk Slöjdlærerforening, 1938: p.41).

In 1889, the Danish Association of Craft Teachers gave away eight physical models in a craft competition, suitable for use in Latin and public schools. In this collection was a torsional modulus of elasticity, a pendulum rack and equipment for thermal conductivity and freezing. The assessment committee, consisting of Mikkelsen (1849-1929), Slomann and Trier, stated: '*This path creates a connection between craft education and physics, which will be of great practical importance in both subjects; it is a good attempt to draw an unprecedented ideal as part of Danish craft education'*. (Dansk Slöjdlærerforening, 1938). Mikkelsen, the originator of Sloyd within Danish schools, taught science-craft to his teacher colleagues via in-service teacher courses, in order to prepare them in becoming craft teachers (Dansk Slöjdlærerforening, 1938: p.38).

The Estonian National Curricula 2011

School attendance is obligatory in Estonia for all students aged 7-17, meaning that they spend a total of nine years in public education. There are three stages to public education: grades 1-3 and grades 4-6 (primary education) and grades 7-9 (lower secondary education).

Attendance at school is obligatory until the accomplishment of basic education or until the student is 17 years old. Study in basic school consists of the first stage of study (grades 1 to 3), the second stage of study (grades 4 to 6) and the third stage of study (grades 7 to 9). The usual length of time for upper secondary school is three years (Andersen, 2003; Pöhikooli-ja Gumnaasiumiseadus, 2010). After finishing basic school education, students can continue their studies in a vocational school and, upon obtaining secondary school education in a vocational school or in an upper secondary school, they can go on to higher education, via either an institution of professional higher education or a university (Eesti Vabariigi Haridusseadus, 1992).

Subjects taught within craft and technology in Estonia support students in gaining the mindset, ethics and values integral to contemporary society. They learn to identify the choices they have in solving tasks or fashioning goods in an environmentally friendly manner, through the use of sustainable procedures. During lessons, students learn and examine phenomena and circumstances, utilising various sources of information. They integrate creative thinking and physical activity. During their studies and making of products, students ideate, design, plan and model, fashioning objects/products and then learning how to present them. The teacher supports students' initiative, entrepreneurial spirit and creativity and teaches them to appreciate a healthy lifestyle and economy. Classrooms are seen as a positive environment where students' work and development are recognised. Through their studies, students develop their ability for working and collaborating and strengthen their critical thinking, including the capability to examine and assess (The Estonian Ministry of Education and Research, 2011b).

The subject field of Craft and Technology includes the following subjects: Handicraft, Technology Education and Handicraft and Home Economics. Handicraft is first taught in grades 1 to 3 for girls and boys together. After grade 3, students are divided into study groups based on their wishes and interests, selecting either Technology Education and Handicraft and Home Economics. This allows students to study in larger detail the subject that they are interested in. There is a compulsory exchange of the subjects each year. In addition, a project-based learning, supervised each year by both teachers, is conducted for about 25 % of the school hours. These projects are integrated with projects in other subjects or conducted between different classes as well as with schoolwide and longer-term events between schools (SFT, 2010; NC, 2010).

Craft and Technology, within the Estonian National curriculum, aims to facilitate students' technological reasoning, in order to get them ready to take part in the modern working life and society. Students gain handicraft skills via the development and making of prototypes and systems and learn about science and technology as a field of human activity, using various tools from different design contexts associated with information and materials and transformation of energy, (NC, 2010). The students' handicraft training increases their skills and an opportunity to utilise and learn about various technologies. Students put ideas in practice by making practical projects and the knowledge gained are applied. Students have to study and analyse phenomena and situations, using various sources of information.

Focus on Cross-Curricular Activities

Since the inception of Sloyd in Estonina, craft subjects have been developed in accordance with various social and educational needs; thus, the ideology and goals of craft education and general education are different. One of the focal points in modern education is inter-subject integration, in terms of its benefits in enabling individuals to understand and use modern technology and to play an active role in the evolution of a modern democratic society (Kuusk, 2010). The integration of subjects decreases the gap between them and overcomes their isolation. By combining the knowledge and skills attained from different subjects, students may improve their understanding of the everyday world outside school (Hitsa, 2019; Autio, Soobik, Thorsteinsson & Olafsson, 2015; Vars, 1991).

In 2010, the Parliament of the Republic of Estonia introduced a new law for comprehensive schools and high schools and a new rationale was subsequently presented within the new national curriculum. The aims of the new curriculum were to create systematic inter-relations between subjects in order to enrich students' learning experiences. Furthermore, there was a focus on developing students' general competences and avoidance of overloading them. In view of the cross-curricular aims, curriculum development must contribute to the fulfilment of the general educational goal of increasing students' skills, in terms of utilising knowledge of natural sciences in various areas and increasing their interest in technology and technological studies (Haridus- ja teadusministeerium, 2011a).

The Estonian National Curricula focuses on increasing students' general competence in technology and this is achieved by giving students cross-curricular learning tasks based on identifying and analysing certain technology in order to be able to create knowledge and use this to solve problems. This is further described in section 1.5.1 of the National Curricula, which states: '*focusing on technology inside craft education relies on knowledge acquired in other subjects, offering opportunities to achieve, through applied activities, an understanding that all knowledge is connected and applicable to everyday situations. Abstract analysis is supplemented with possibilities of seeing, touching and testing, which lead to a visible result. Subject projects enable connections to be made between subject fields, within the subject field and with other subjects*' (The Estonian Ministry of Education and Research, 2011a, p. 327).

A Survey to Examine Students' Abilities in Utilising Knowledge of Other Subjects within Craft Education

At the end of the 19th century, the Estonian education system was already concerned about the chaotic presentation of study material, in which links between new and old material were missing (Lind, 2005). They were also concerned there were too few students graduating in subjects within the remit of science and technology.

One important indicator of students wanting to obtain a profession within the area of science and technology was viewed by educators as the awareness of comprehensive school graduates to utilise knowledge of applied sciences in solving work-related problems. To clarify this, a test was conducted in Estonia in the spring of 2005 (Kikkull, 2009), involving students in the final year in comprehensive school. The tasks measured students' abilities in utilising basic mathematics and physics to solve general technical problems. The participants were all boys and the test was conducted in both town and country schools. The research concluded that the students' skill in solving technical problems were generally poor.

The most difficult task the students faced could be solved by applying mathematics. They had to calculate how much paint was needed to cover a plywood surface according to its surface area and only 29% of students were able to answer the question. A particular difficulty they had was calculating the size of the surface area upon having identified the geometrical shape of the object. Tasks that required knowledge of physics, however, were managed much better (with a success rate of 74%) than those tasks that required knowledge of mathematics (success rate of 42%). The research concluded that physics-related tasks were closer to real-life technical situations than those tasks based on mathematics and thus were more appropriate for students. It also highlighted students' difficulties in solving tasks within craft using knowledge from different subject areas.

Methodology

The aim of the research study was to examine Estonian schoolteachers' attitudes to utilising knowledge of applied science in order to support craft education within Estonian comprehensive schools.

The objectives were to:

a. *Examine the role of teachers in this context*
b. *Identify any pedagogical issues relating to the use of science knowledge in support of craft education*
c. *Observe the learning process in action, in terms of scientific knowledge*
d. *Observe if any applied knowledge was in use during lessons*
e. *Observe if there was collaboration amongst teachers.*

The research questions were as follows:

1) *Do Estonian craft teachers follow the National Curricula, in terms of utilising science knowledge in support of craft education?*
2) *Are teachers aware of those times when science integration arises in their teaching?*
3) *What do teachers consider the benefits of such integration?*

The research was based on twenty semi-structured interviews with school teachers from various regions within Estonia, in order to establish their attitudes towards the integration of science with craft. Five of the teachers were with a master's degree. Having teachers with a wide range of roles and experiences helped to ensure quality, reliable data.

In semi-structured interviews, researchers normally use open-ended questions, which require descriptive answers (Smith, 1995). The aim of this is to gain respondents' points-of-view, rather than generalising about their behaviour and activities (Smith, 1995). Throughout interviews, the interviewer applies suitable probing techniques, which encourages participants to speak further (Cohen, Manion & Morrison, 2005). However, such probing has to be neutral so that it will not redirect interviewees to other subjects.

The researcher attempts to build a rapport with respondents, with the interview taking the format of a conversation (Smith, 1995; Willig, 2001). Questions are asked when the interviewer feels it is appropriate to ask them and these may be prepared questions or questions that arise in the researcher's mind during the interview. This sense of rapport implies ethical responsibilities and interviewers have to be sensitive, with regards to respondents' readiness to talk about prearranged topics. Semi-structured interviews are designed to create a detailed description of respondents' perceptions of a given matter (Cohen et al., 2005). In half open interviews the researcher has the responsibility of ensuring that the interview does not diverge from the research question (Cohen et al., 2005) and a carefully constructed schedule can help with this (Smith, 1995; Willig, 2001).

All interviews were based on a semi-structured interview schedule developed from the literature and the survey, as many questions were addressed by interviewees' personal stories. The software Transana 3.21 (Transana, 2018) was used to analyse the data arising from the interviews and open coding was used in data analysis, in accordance with grounded theory principles. In open coding, researchers form initial categories of information regarding the phenomena that was examined (Creswell, 1998). They approach the data with open minds, in order to generate as many ideas and issues as possible. Similar results are categorised into main categories and are drawn upon in discussions and conclusions (Emerson, 1995).

The data was processed as follows:

1. *Raw data was collected;*
2. *Data from each interview was then summarised: for example, the teacher interviews were first summarised separately and then placed together, in order to generate categories;*
3. *These categories were then interpreted. Patterns were identified and connections made creating a coherent narrative with quotes from the interviewees;*
4. *Conclusions drawn;*
5. *The process was repeated for all the interviews listed above;*

6. *Finally, the categories from all data sources were brought together under overall categories;*
7. *The categories were then used to triangulate the findings and were analysed in relation to each other and the literature and conclusions were drawn.*

Discussing the Results Arising from the Enquiry

In this section, main categories established during the enquiry are defined and the results outlined:

a. *Learning to Use Hand Tools and Machinery*
b. *Integration and the Craft Syllabus*
c. *Integration of Craft and Applied Sciences*
d. *Teacher Cooperation*
e. *The Effects of Integration*
f. *Realisation of Integration*

a. Learning to Use Hand Tools and Machinery

The research shows that the students, in general, learn to use hand tools before they learn to use machinery. They gain technological knowledge and skills via learning processes that are largely based on their own experiences. However, they sometimes use hand tools and machinery together, but this is dependent on the aims of a lesson. Also, if the teacher considers manual work too demanding, materials may be prepared using machinery before the utilisation of hand tools. As Kirkull (2009) stated, machine work is not a good method with which to teach handicraft. He further claimed that by undertaking work manually and then finishing it off using machinery, students can both gain knowledge of the use of machinery and the satisfaction and pride in handicrafts: gaining knowledge and a deep understanding and respect in the value of craftwork through the use of hand tools is an important aspect of craft. Some scholars argue that, if students are to effectively learn about the use of technology, such as machinery (Hubber, Tytler & Haslam, 2010), they must be conscious of concepts and processes and the associations between them in order to understand these within the context of technological and scientific knowledge (Prain, Tytler & Peterson, 2009).

Teachers were often excluding students from using machinery due to safety regulations. They also asked them to avoid becoming too dependent on the use of machinery in order to develop their handicraft skill (for example, when they queue to use a machine for a single minor cut). Due to this, the teacher has to establish a syllabus with rules that support the relationship between learning to use hand tools and machines, based on logic and scientific knowledge of machines and safety rules. Suchman (2007) considered that there is a focus on interrelations between human beings and machines inside the craft classroom (Wallace, 2010). Furthermore, he argued that there are interrelations between technological artefacts and working culture (Hasse, 2011) and between sensing and technology (Søndergaard, 2009). Thus, the philosophy of technology is able to take into account the connection between humans and technological knowledge (Dakers, 2005, 2006; Ihde, 2010; Ingerman and Collier-Reed, 2011).

Teachers feel that hand tools offer greater potential in explaining the various aspects of work processes. This may derive from the fact that, when working with hand tools, the student experiences the material with his other senses. Maintaining handicraft skills is also regarded as important because it improves students' sensory motor skills. According to Borg (2006), it is better to perform craft processes in order to understand them and to become familiar with them. Moreover, the improvement of practical handicraft skills equips students with the opportunity to learn about and utilise numerous technologies during their design-making (Kikull, 2009). Students put ideas into realisation through practical work and the skills and knowledge gained are not only practical in terms of creation of new products, but also in the understanding of existing products, machines and other objects (Thorsteinsson and Olafsson, 2016).

b. Integration and the Craft Syllabus

When teachers set up their school syllabus, they must follow the National Curricula and be critical, in terms of weighing up the any benefits for the subject of craft. In general, it is also wise to reflect upon and evaluate new ideas and approach them with an open mind. This can help a teacher to validate new ideas and thus ensure reliability and confidence in further actions (Tart, 2009). The present national curriculum is focused on integration and, generally, encourages teachers to approach craft working with general topics and, when building up general skills, integration is also handled in a cross-curricular way (Government of the Republic, 2014). However, some teachers simply understand this as an innovation in craft education (Kirkull, 2016).

Craft teachers write their own syllabus, but do not always follow the national curriculum. They generally adjust the syllabus in accordance with their prior knowledge, rather than placing new emphasis on the national curriculum. Though the syllabus did not lead them directly towards integration, participants in the research believed that craft involved inheriting knowledge from other subjects, particularly mathematics and physics, and that a good teacher might identify these connections and utilise them in the classroom. According to Syrjäläinen, (2003: 60) teachers build metacognitive supporting structures for the student when they finish different tasks, problems or learning objectives.

A syllabus may also guide teachers by emphasising the use of scientific knowledge in craft, but is a document that provides teachers with freedom and flexibility: it does not necessarily direct craft teachers to integrate their subject with applied science, but it does not forbid it. As expected, teachers are afraid to move towards science and consider that craft may become a supplementary subject under science. As Akgun, Isik, Tatar, Isleyen & Soylu. (2012) argued, although much has been said about the need for integration, subjects in basic schools have remained largely isolated.

Most Estonian craft teachers, according to Kirkkull (2012), base their teaching on reproduction of known artefacts. Therefore, students have difficulties to use theoretical knowledge they have learned to solve live situations because they have not used it to solve problems through practical work inside craft classes. Insufficient use of possibilities to integrate science knowledge with craft during lessons may be the main reason why students cannot use knowledge from science outside the school. Moreover, more time needs to be given for creativity and experimentation (Kikkull, 2012). That would offer students to implement knowledge from other subjects' areas to resolve tasks during lesson.

c. Integration of Craft and Applied Sciences

Teachers in the study believed knowledge of applied sciences, in terms of craft, to be both practical and beneficial. They also considered some elements of applied sciences or science as an integral part of craft, stating that applied sciences were always present, but that it is important to clarify their presence when working with students as they have difficulty in identifying this.

Science, technology and craft are connected. Science explains how technology works and the usefulness of scientific knowledge becomes very clear when technology is utilised in craft. Undertaking handicraft within Craft lessons provides students with opportunities to learn about and utilise various technologies, via hands-on. The knowledge and skills gained are applied not only to the making of new artefacts, but also to the adaptation of existing technology and the maintenance of machines or handicraft tools. Gaining practical skills can facilitate both scientific knowledge and understanding through technological reasoning and makes it easier for students, to solve world problems (Thorsteinsson & Olafsson, 2016; Malone, 2016). Ainsworth (2008) underlined that importance of being able to explain applied science in many ways and the importance of giving students information from many sources as it would deepen their understanding in science.

According to Perkins and Salomon (1992), the utilisation of knowledge of applied sciences in craft is vital, as it helps students to view the world around them holistically and from different angles. Students, however, usually consider subjects as detached and separate from each other, with no direct connections. Also, in such learning situations, the formation of students' comprehensive view of the world is not supported (Kikkull, 2016).

The teachers considered that sciences were very theoretical and far removed from any practical work and argued that teachers must learn the practical aspect of the subject, in order to be able to apply it in the classroom. They also asserted that the integration of applied sciences in craft class projects a rather dull and uncreative phenomenon. While a variety of integration approaches can be found in theory (Mustafa, 2011) and the Estonian

National Curriculum for Basic Schools (Government of the Republic, 2014) sets out the requirements for the realisation of integration, teachers lack the knowledge and experience of functional principles and the directive role of syllabi and textbooks have to be moderated (Kikkull, 2016). The research indicated that the integration of any subjects in schools was weak and that subjects were isolated, due to the structure of the national curriculum. The best integrationists were those teachers who taught two subjects; e.g., a craft teacher who also taught mathematics. Akgun et al. (2012) stated that, although much has been said about the need for integration, subjects in basic schools have remained mostly isolated for both Estonian as well as foreign studies (Akgun et al., 2012; Kikkull, 2009; Soylu & Isik, 2008) They demonstrated that students' subject knowledge remains significantly below if they don´t get an opportunity to utilise the subject knowledge of natural sciences in various areas.

Teacher participants in the research believed they were utilising applied science via the craft process, but that it was also both important and beneficial for students to understand it theoretically during classes in other subjects. The use of applied sciences enables students to better plan their work and the teachers also considered it important for students to gain intuitive information in order to enable their understanding of different principles via practical craft lessons. This ability to receive intuitive information has been referred to in various ways in the literature: The psychologist Tart (2009) called it *direct knowing* and it has also been described as ……*naked-awareness* (Targ, 2004). Many craft scholars and researchers describe having experienced information acquisition during their work (Larsson, 2001; Uusikylä, 2008).

The craft teachers who took part in the study were independent but knew little about how teachers can utilise applied sciences in craft. They understood the value of experiments within applied sciences, but were not ready to adopt this as part of their daily routine, with one stating: *Teacher do not interlink subjects; it is not common for them to see relations with other subjects in terms of making with your hands.* Perhaps the teachers just needed support to get started in this. Braunger and Hart-Landsberg (1994) noted that teachers implementing integrated education require help in overcome the inertness of acting alone. Other researchers have addressed support for interdisciplinary integration, such as Jacobs (1991) in his recommendations for the effective application of integration and Drake (1993) in his discussion of teachers' misconceptions about integration.

The teachers argued that teacher training was too subject-centred to prepare teachers for the integration of subjects and that, later, this would depend on their own initiative. Teachers should work together, given that the fundamental principles of craft and science are easily combinable. Younger teachers, open to new ideas and directions, would also be more likely to work with integration than teachers with longer work experience. While a variety of integration approaches can be found in theory (Mustafa, 2011) and the Estonian National Curriculum for Basic Schools (Government of the Republic, 2014) sets out the requirements for the realisation of integration, teachers lack knowledge and experience regarding functional principles and the directive role of syllabi and textbooks is moderate (Kikkull, 2016).

Participants in the study believed that applied sciences have a slightly higher hierarchical position than craft, but stated that people require such skills for solving real-life problems. However, they considered examples and demonstrations in applied science classes too subject-centred and not conducive to real life. According to Kikkull (2009, 2016), the learning process in basic schooling is characterised by conflict between the natural integration of craft and other subjects and the realisation of this. Such conflict affects students' ability to apply subject knowledge outside that specific subject; i.e., they lack the readiness to use acquired knowledge in solving real-life situations, particularly concepts and skills that they have not yet learned directly.

The teachers underlined the importance of teaching students everyday problem-solving through the application of theoretical knowledge, as this helps them to function in society. As one of the teachers said: *People do not just consider the theoretical aspect of processes, they simply undertake them. The student for example has to know how glue works in order to be able to glue wooden pieces properly together.* Regretfully, the teachers did not fully acknowledge this problem. According to Skolverket (2005), within the subject of craft, it can be clearly seen that students are in tune with practical problems, but that skills gained are rarely visible outside the classroom.

d. Teacher Cooperation

The teachers, most often, worked alone rather than together but communicated regularly during meetings. However, when schools were running interesting theme weeks or a single project, there was active teacher cooperation. Co-operation between craft and science teachers is not an everyday occurrence. Most cooperation was achieved with maths and physics teachers, the benefit of which is viewed by craft teachers as students' awareness of cross-subject relationships (Kirkull, 2016). Craft teachers are generally cooperative and open-minded and are ready to engage in various forms of cooperation with teachers of other subjects; however, they require the organisational support of their school in this (Kikkull, 2016).

Teachers felt their cooperation could be better, but considered it time-consuming as it required extensive planning. They also considered school subjects were competing for time. One teacher said: *Regretfully, at the moment, due to the number of classes and volumes of class curriculums, subjects are more competitive than cooperative.* An analysis of the study showed that Estonian teachers feel overloaded; they lack resources and subjects are separated within schools. Similar issues were also highlighted by Braunger and Hart-Landsberg (1994), who noted that teachers implementing integrated education required help to overcome the inertness of acting alone.

e. The Effects of Integration

All interviewees considered integration should be based on a single subject supported by using knowledge from other subject areas. They found craft in combination with applied science a good method of helping students to understand world phenomena. Understanding such phenomena and patterns via craft can help students to understand the world from a theoretical viewpoint; thus, craft ought to be utilised as a tool to understand applied sciences. According to Kikkull (2009; 2016), schools should integrate craft with other subject in natural manner via practical work as it would help students to better understand the world around them and to solve real-life situations.

The teachers argued that craft can make mathematics enjoyable for students, rather than it being a difficult and abstract subject. They stated craft was rated of high value amongst students and that this may also increase their interest in applied sciences. It was believed that students' interest in studying technical subjects is dependent on how the teacher stimulates interest in students. A teacher can be a guide, but general craft studies do not prepare students for any specific profession. It is important to meet students' interest, but difficult to meet every students' needs. Both Estonian and foreign studies (Akgun et al., 2012; Kikkull, 2009; Soylu & Isik, 2008) have shown that students' subject knowledge remains significantly below the level required to solve domestic and technical problems.

f. Realisation of Integration

During craft classes, teachers integrate applied sciences without acknowledging it themselves, through demonstrating, testing, experimenting and explaining applied phenomena noted throughout the work process. Problem-based teaching and process-thinking is often used, which in turn encourages students to define and solve problems (Kikkull, 2012). There is an attempt to find suitable tools, materials and processes in order to solve problems, followed by experimentation and analysis of the outcome. Subject integration seldom takes place, in terms of cooperation between two teachers on the basis of an optional subject. Current perspectives on knowledge, according to Petrina (2007), questioned the view that knowledge is information, or a collected database that can be used when the circumstance arises. He further argued that knowledge is passive in the process of craft and technology and that it is utilised when required.

The aim of craft education is not to demonstrate the phenomena of physics, but to deal with problems within craft. Students, normally, focus on making objects rather than studying applied science. Teachers believe students have difficulties in understanding abstract concepts and find it hard to establish whether information originated from one specific subject. The key to this is for students to solve problems on the basis of what they already know. Borg (2006) argued that, in order to understand the processes relating to craft in the environment around us, it is best to perform the processes ourselves and thus be convinced of their validity. Knowledge, according to Petrina (2007), generates action and, of course, action or experience generates knowledge. Knowledge is both the process and product of innovative act.

The teacher plays a vital role in this situation. He can guide students through the working process; they make them achieve quality work, even if they do not understand the process very well. It is thus better to give students support in understanding new knowledge during their work. He has to give them flexibility so that they can make their own decisions and finally understand problems through experience. However, the risk with this teaching method is that a student may not gain enough knowledge of materials and tools and thus improve his craft skills. Therefore, the best teaching method would be both to guide and support in order to ensure students fully understand concepts: this also occurs through students' reflections and communication. The connection between a teacher and a student, moreover, consists of multiple interconnected perceptions that arise from their interactions (Pianta, Hamre & Stuhlman., 2003).

Conclusion

The research focused on integration of craft education and applied sciences in Estonian comprehensive schools. The data indicates that, applied sciences within the comprehensive school remain isolated within their subject fields; thus, students are unable to apply any acquired knowledge outside of the school environment and they lack the motivation to seek such knowledge. They also lack the mindset required to apply their knowledge of science in order to solve problems, both at school and in their daily lives (Kikkull, 2009).

A well-organised integration of craft and applied sciences in comprehensive schools would perhaps help to overcome the aforementioned situation. The integration method currently used in schools lacks efficient planning and should be visible in curricula guidance for teaching, schoolbooks and teaching materials. In-service course training for practising science teachers also lacks an introduction of applied teaching principles and algorithms in its didactics.

The authors of this research address the aforementioned problem and hope it will assist educators within the area of craft and science, in order to develop principles and measures for forming integrative knowledge in students. This could be the basis for:

- *Improving understanding of technical phenomena through an exploration of their scientific nature*
- *Applying knowledge of applied sciences in other subjects*
- *Motivating students' willingness to learn applied sciences*
- *Motivating students to undertake technical studies after compulsory education.*

Generally, Estonian craft teachers teach students handicraft and machine work via trying, testing and experiencing, rather than building upon technological knowledge. Thus, utilising knowledge of applied sciences may be beneficial for the learning process in craft. The need for knowledge is greatest during the work process: it is vital in students gaining a sense of both material used and work processes. As Borg (2006) asserted, in order to understand the processes that relate to craft in the environment around us, it is best to perform the processes ourselves and thus be convinced of their validity.

The craft syllabus offers little help for teachers, in terms of the integration of science. It falls to teachers to utilise knowledge of science in craft lessons and this is dependent upon their own awareness, initiative and values. There is no doubt about the necessity and usefulness of integration, but there are some conditions on its introduction:

- *It should be interesting and motivational;*
- *A craft class must maintain its subject focus and not become an ancillary subject;*
- *Integration must shape a consistent world-view, not simply a strict understanding of a single applied sciences subject;*
- *An attempt to organise teaching on a topical basis by teaching supra-subject topics of similar substance simultaneously in different classes;*
- *Integration should be based on problem solving and analysis of the work process.*

As subjects are isolated, due to the curriculum, an initial step towards integration could be to utilise the capabilities of those teachers who already teach two subjects. Teacher training in craft should also be based on integration.

Answering the research questions

The three research questions set in the beginning are answered in the sections below:
Question one: *Do Estonian craft teachers follow the National Curricula, in terms of utilising science knowledge in support of craft education?*

Answer: The teachers, in general, follow the National Curriculum but many of them do not follow it in terms of applied science. They rather write their syllabus in accordance with their prior knowledge and skills. Their teaching is based on reproduction of known artefacts instead of focusing on integration and applied science and students' have limited freedom to create their own designs. Many of the teachers, also, consider integration and use of applied science a useless innovation in Craft, particularly mathematics and physics. Teachers are afraid to move towards science and consider that craft may become a supplementary subject under science.

Question two: *Are teachers aware of those times when science integration arises in their teaching?*

Answer: The teachers, in commonly, considered a good teacher able to identify connections between craft and applied science and capable to utilise them with students inside the classroom without being supported by the National Curriculum.

Question three: *What do teachers consider the benefits of such integration?*

Answer: All of the interviewees considered craft in combination with applied science a good method of helping students to understand world phenomena. They, moreover, thought that understanding such phenomena and patterns via craft could help students to understand sciences, mathematic and the world around them. They, also, considered such understandings were required for solving real-life problems. The teachers argued that craft can make mathematics enjoyable for students and science more interesting, rather than considering it being difficult and abstract subjects. They also believed that students' might become interested in studying technical subjects.

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