26.3
Part 1

Design and Technology Education: An International Journal

Design and Technology: An International Journal

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Editorial
Special circumstances, Special issues.

Kay Stables, Goldsmiths, University of London, UK
Lyndon Buck, Aston University, UK

This current issue of Design and Technology Education: An International Journal arrives as, globally, we continue to live with a pandemic that has certainly inflicted special circumstances on education. From early years education to studying for a doctorate, things have been different, challenging, frustrating. At times there have been surprises, innovations, insights, new ways of working. Capturing experiences, both negative and positive entered our thoughts as editors. Taking note, of what emerged through the special circumstances of educating during a pandemic seemed important. So when we were approached in the initial era of 'lockdowns' to have a special issue providing research insights from learning and teaching in the pandemic, we were happy to say yes. A different special issue was also being prepared at that time – a 'special' being created with articles developed from the Engineering and Product Design Education (E&PDE) conference, 2020. Alongside both, regular articles were being submitted to the journal in the standard fashion. As these three separate strands progressed a zeitgeist situation began to emerge. A call for articles for the special issue commissioned to focus on the pandemic, being guest edited by Derek Jones and Nicole Lotz from the Open University (UK) drew far more interest than imagined and is now in the final stages of being prepared for publication as a stand-alone issue of the journal (Volume 26.4), due to be published next month. The E&PDE conference of 2020, like many other conferences, became a virtual conference, as was the 2021 conference – special circumstances. Despite special circumstances, the E&PDE Special Issue, guest edited by Ross Brisco (University of Strathclyde, UK) and Anne Louise Bang (VIA University College, Denmark) is published as Part Two of this current issue. Meanwhile, the 'regular' articles have been prepared and, zeitgeist being in the air, three of these articles also report on research carried out during the pandemic. So, special circumstances have spawned special issues, capturing special insights, innovations and developments that will inevitably impact on the future of design and technology education. But now to Part One of this issue.

In *Teachers' perceptions of social support in the co-planning of multidisciplinary technology education,* Hanna Emilia Aarnio and Maria Clavert from Aalto University, Finland along with Kaiju Kangas and Auli Toom from the University of Helsinki, Finland explain that in Finland technology education is multidisciplinary but that pre-service teacher education does not fully prepare new teachers for this. There is previous research on multidisciplinary team teaching but the authors focus specifically on their research that explores the social support that can be involved in co-planning multidisciplinary technology education. Through interviews with experienced teachers from across all levels of school education who were involved in a pilot in-service course on multidisciplinary technology education, the value of instrumental, emotional and informational support were identified. It emerged that instrumental support introducing new ideas, tools and methods were valued and of particular importance was a perceived need for social support in joint decision making. The authors highlighted a need for more support for pedagogical leadership to move forward with multidisciplinary technology education. While there is value for all teachers in insights provided into co-planning and teaching this article will be of additional interest to those introducing or currently teaching in STEM or STEAM teams.

In *Industry 4.0 Competencies as the Core of Online Engineering Laboratories*, Emmanuel Garcia-Moran, Donovan Esqueda, Jose De Jesus Solis-Cordova, Luis Villagomez and Hector Morano from the Tecnológico de Monterrey, México and Rafael Ramirez from Tenneco – Federal-Mogul, México, focus on the increased use of online laboratories in engineering education, particularly highlighted as a result of the Covid-19 pandemic. While identifying that learning techniques such as Problem-Based Learning, Project-Orientated Learning and Research-Based Learning are used online, they highlight a lack of focus on Industry 4.0 competencies. Their article focuses on a pedagogical approach wherein Industry 4.0 competencies are introduced in a way that complements existing learning techniques. The article provides insight into the impact of a series of courses developed and introduced with undergraduate students during 2020. The article presents research on students' self-efficacy, highlighted by the team as being of importance in the context of introducing Industry 4.0 competencies in an online learning situation. There were two major focuses – the students' physiological states (particularly given the situation of the pandemic) and their mastery experiences. Through an exit-survey with 300 students three indicators were measured: students' perceived usefulness, perceived ease of use and perceived efficacy. The article reports on both positive reactions such as how quickly students adapted to the online setting and an importance of remote laboratories and specialised software and also the challenges, both pedagogical and practical. Given the shifts towards more online learning not just in engineering education but also generally in design and technology education, this article provides valuable insight into ways of making pedagogical shifts and impacts on students along with further understanding on student self-efficacy.

The following three articles provide insights into aspects of designing and design processes.

Catarina Lelis from the University of Aveiro, Portugal presents and article that focuses on students' final projects. In *The Impact Plan: anticipating the impact of university students' final projects*, she highlights the significance and potential struggle of students choosing a topic for their final project as they consider its potential value and impact. Her article presents a tool that is specifically designed to assist students as they manage decision making influenced by the potential impact of the project alongside their own personal interests, career ambitions and how they can contribute to a better world. he reports on the use of the developed tool, *The Impact Plan*, with students on a postgraduate programme. Focusing on the principles of 'Why' and 'Value', a prototype was developed, made up of a canvas for students to map notions of value and a deck of cards focusing on different categories of impact. The tool was implemented in 2020 during a period of 'lockdown in the pandemic with 25 students working in small teams, supported by former graduates acting as mentors. The tool enabled students to identify possible projects and then score them against likely impacts. The structure helped remove anxiety from students making decisions about final projects. Whilst the study was small scale, involving 25 students, insights gained were on the value of the tool from both student and lecturer perspective and also on aspects related to student groupwork during a pandemic. It also highlighted possible future development of the tool, particularly its value in group work. Despite being undertaken with postgraduate students, the tool will be of interest at any level of education as a way of supporting design thinking when making choices about project work.

The next article also focuses on the early, conceptual stages of design. In *Inquiry-based learning approach for a systematically structured conceptual design process: Design project for disabled people*, Güçlü Yavuzkan and Figen Beyhan from Gazi University, Turkey and Özden Sevgül from Siirt University, Turkey, present a further small-scale study, also undertaken online during the pandemic. In this project the topic of 'Design for the Disabled' was chosen as a social design project that provided a context for exploring the 'fuzzy front end' of a project. As with Leilis's article, the challenge of this early decision making stage for students was noted. The article reports on a toolkit that focuses on conceptual design, Inquiry Based Learning and developing critical thinking skills in which students are guided through analytic, creative and visualisation stages. Examples of projects illustrate how different students progressed through these phases and an analysis of post-project student questionnaires provides insight into how the students rated their experience of developing critical thinking, professional skills, systematic thinking and personal development. In all aspects the ratings of the students suggested that the approach was more effective than previous less structured approaches. The lecturers' assessments were also generally favourable. The authors suggest that a large scale study is needed, but this small study has indicated the value of the approach. For readers, this article has the value of an in-depth account of different dimensions and interpretations of design processes. Also examples presented through case studies of student projects illustrate the impact of the authors' particular focus on a conceptual design process at the 'fuzzy front end' of a project.

A third article focuses on design process in the context of architecture education. In *An Experimental Framework for Designing a Parametric Design Course* Asli Agirbas from Ozyegin University, Turkey highlights the impact that computer-aided design (CAD) programmes are having on architectural knowledge and form and on design thinking and design process. Noting that architecture programmes vary considerably, he outlines the development of a framework that can be used to design parametric courses in different circumstances. The framework categorises university profile, course profile and student profile and then evaluates an architecture department in three categories: 'open to new design approaches', 'supportive of CAD' and 'reject new design approaches'. A case study using this framework is presented, providing detail of curriculum, choice of CAD programmes and approach, existing student design experience, parametric design tools to be used and so on. Student work is then used to exemplify the approach in practice. The author uses the student work to illustrate how the framework supported students' in building on existing knowledge and experience and moving forward their architectural design knowledge and skills. Acknowledgement is given to the need for a further independent study to fully evaluate the approach, but even at this initial stage the article provides valuable, concrete approaches to introducing CAD in a way that could help a department evolve its curriculum in a supportive and developmental fashion.

The next article shifts attention to a completely different focus – the impact that education policy can have on areas of design and technology curriculum. In *A-Level Food: The gap that remains: A research project on the impact of removing post 16 A-Level examinations for Home Economics and Food Technology in schools in England in 2016,* Louise Davies, Founder: Food Teacher's Centre UK and affiliated with St Angela's College, National University of Ireland, examines what happens at the school level when a curriculum change at a national level is dictated. The article focuses on the removal of a national curriculum and assessment route in post-16 education - Home Economics A-Level (Advanced Level). This broke the chain between a school subject and higher education programmes and career pathways. The research focuses on teachers' experiences from 2016-2020 and impact on the progression pathways to further study and employment opportunities. Interview participants identified from a large scale study on the topic completed a short, open ended questionnaire and engaged in a semi-structured interview. The article reports the teachers' experience of reductions in numbers on food related courses post-16 and the narrowing of the curriculum and the identification of a need to re-instate an A level in food technology to re-create a progression pathway. The article is a sharp reminder of the impact that policy changes can have on curriculum.

The final article provides insight into an aspect of design and technology education that has seen limited attention – that of the potential impact of different generations of educators on learning and teaching. In *Industrial Design Education: A Research on Generation Theories and Change in Turkey* Çisem Ercömert and Serkan Güneş from Gazi University, Turkey provide fascinating insight into the extent to which educators from different generations differ in their approaches. The authors draw on generational theories identifying five categories of generation, based on exposure to historical and cultural events, shared experiences, similar attitudes etc: the Silent Generation (born 1925-1945), Baby Boomers (born 1946-1964), Generation X (born 1965-1980), Generation Y (born 1981-2000) and Generation Z (born since 2001). The research is focused on changing dynamics in design education in Turkey and was undertaken through in-depth interviews with lecturers from different generations working in a Turkish university industrial design department. Interviews were conducted with 24 participants drawn from across generational groups. They explored educational approaches such as learning environments, technology impact, curriculum and teaching methods; studio lessons such as project topics, critique process, design process and studio culture; and relations between student and lecturer. Generational differences within these areas make interesting reading. No plot stealers, but the largest difference occurs in relation to technology. A key reflection by the authors was the importance of structures within education that are open and support change.

Finally, this issue of the journal contains two reviews of recent books.

The first*, Teacher as Designer: Design thinking for educational change* (edited by David Scott and Jennifer Lock, Springer 2021) brings together a wide collection of chapters in three sections that focus on differing perspectives on educational design, key actors within educational design and new possibilities for design in education. Reviewed by Alison Hardy, a higher education design and technology educator (Nottingham Trent University, UK), and Daniela Schillaci Rowland, a secondary school design and technology teacher (Presdales School, UK), chapters are outlined and evaluated in terms of potential interests at school and university level. The review indicates that the book has much to offer design and technology educators at all levels.

The second book review is of *Food Education and Food Technology in School Curricula International Perspectives* (edited by Marion Rutland and Angela Turner, Springer 2020), reviewed by Julie Messenger (Independent Consultant, UK). The collection provides fascinating insight into food education and food technology from across international settings. Structured by three sections, chapters relate to food teaching in schools in different cultures, the professional identity of food teachers, and current content and contemporary issues. The detail and breadth of food education provided across these chapters provides valuable background and 'food for thought' in relation to the earlier article in this issue by Louise Davies.

Design and Technology Education: An International Journal

26.3

Teachers' perceptions of social support in the co-planning of multidisciplinary technology education

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Abstract

In Finland, technology education is a multidisciplinary field where team teaching serves as a basis for the integration of technology across different school subjects. However, Finnish teacher education does not adequately prepare the student teachers for multidisciplinary technology education, and the professional competency is often gained through voluntary participation in professional development courses. The resulting individual differences in teachers' technology education competency hinder their ability to plan such educational offerings together. While previous studies have identified multidisciplinary team teaching as a way of balancing out individual differences in teachers' professional competency, the ability to leverage it depends on the availability of social support. Previous studies have examined the effect of social support in teachers' professional well-being, but further research on its role in organising multidisciplinary technology education is needed. This study explores what kind of social support is involved in the co-planning of multidisciplinary technology education. Eleven experienced in-service teachers representing different school subjects participated in interviews carried out in 2019–2020. The data were analysed by applying the principles of qualitative content analysis. The findings revealed that instrumental support in the form of new ideas, tools, and methods was emphasised in the teachers' experiences. The perceived needs for more social support were mainly related to making joint decisions during the co-planning process. The findings indicate that co-planning in multidisciplinary teams increases the versatility of possible implementations of technology education. However, leveraging multidisciplinary team teaching would require more support for pedagogical leadership.

Keywords

Team teaching, interdisciplinary approach, technology education, co-planning, social support, content analysis

Introduction

There is a growing body of evidence on how early exposure to multidisciplinary technology education motivates adolescents to pursue further studies in technological fields (Daugherty & Carter, 2018; Shalali et al., 2017; Ward et al., 2015; Yoon et al., 2014). As teachers in primary, secondary, and general upper secondary education have a central role in exposing their pupils to technology education across all school subjects, it is critical to understand how they can plan for joint offerings in multidisciplinary teams. Team teaching is a process where two or more teachers collaborate in planning, teaching and evaluation of a learning entity (e.g., Alsarawi, 2019; Pratt et al., 2017; Takala & Uusitalo-Malmivaara, 2012). In technology education, the planning stage often requires understanding of technology and its integration with other disciplines (Bell, 2016; Jones & Moreland, 2004). Previous studies have revealed that teachers have individual differences in their expertise (El-Deghaidy & Mansour, 2015; Fahrman et al., 2019; Stein et al., 2001) and self-efficacy (Hartell et al., 2015; Nordlöf et al., 2019) related to technology education, which is prone to hinder their ability to engage and contribute in the co-planning process. While multidisciplinary team teaching has the potential to balance out these differences (Kafyulilo et al., 2016; see also Salonen & Savander-Ranne, 2015; Voogt et al., 2016), teachers' ability to leverage it depends on the availability of social support from colleagues (see Morelock et al., 2010; Scruggs et al., 2007). Previous research has identified the importance of social support in teachers' professional well-being (e.g., Greenglass et al., 1997; Kahn et al., 2006; Kinman et al., 2011; Russell et al., 1987; Schonfeld, 2001), but research on the role of social support in co-planning of multidisciplinary technology education is needed.

In Finland, technology education is a multidisciplinary and cross-curricular learning entity that is not bound into any single framework or school subject. The Finnish national core curriculum for basic education promotes technological understanding as a transversal competency, which should be integrated into the learning objectives of all school subjects (Finnish National Board of Education, 2014; Wang et al., 2019). Although teachers are allowed to organise their multidisciplinary teaching of technology freely (Härkki et al., 2020), Finnish teacher education does not adequately prepare student teachers for either technology education or team teaching. Consequently, the professional competency of multidisciplinary technology education is often based on in-service teachers' voluntary participation in professional development courses.

One of the possible ways for organising team teaching is a sequential approach, in which teachers of different school subjects take turns to introduce an independent, subject-specific and sometimes contradictory perspective to the topic at hand (Wenger & Hornyak, 1999). When organising team teaching as distinctions, each subject teacher introduces a complementary perspective to the common topic (Wenger & Hornyak, 1999). For example, a craft teacher may support pupils in working with prototyping materials, while a mathematics teacher advises them in computer programming. This way of organising team teaching may also be referred to as a simultaneous approach, in which two or more teachers combine their efforts to teach pupils in a shared space (Cook & Friend, 1995). For example, Finnish primary level class teachers are qualified to teach all school subjects, which lowers the threshold for collaborating with other teachers in a shared classroom. The most complex approach to team teaching is dialectic exchange, where teachers develop, evaluate, and synthesise different subject-specific ideas before introducing them to the pupils (Wenger & Hornyak, 1999). For instance, a team of subject teachers in music, arts, and biology can organise an open-ended learning process, where they approach technology by combining ideas from multiple subjects at once.

This study examined what kind of collegial support is involved in the co-planning of multidisciplinary technology education in Finnish primary, secondary, and general upper secondary level schools. To attend to this aim, the theory of social support (Cobb, 1976; House, 1981) was applied to identify teachers' experiences of emotional, instrumental, and informational support during the co-planning process. The following research questions were addressed:

1. What kind of social support do teachers receive in multidisciplinary technology education?
2. What kind of social support do teachers need in multidisciplinary technology education?

Theoretical Framework

Co-planning in multidisciplinary technology education

Technology education is still an emerging field; in most countries, it has been developed only over the past two or three decades (de Vries, 2009). It is often considered to have its roots in craft, vocational, and science education (de Vries, 2018). In the field of science, technology education has been situated in the framework of science, technology, engineering, and mathematics (STEM), which was introduced in basic and secondary education in the 1990s (Bybee, 2013; Land, 2013; Sanders, 2008). Recently, the STEM framework has been enriched with the 'A' representing arts, humanities, and design (Bequette & Bullitt Bequette, 2012), shifting the focus towards a more multidisciplinary and creative problem-solving process (Jones et al., 2013; Williams, 2012). The transition to the STEAM has been fueled by the need to educate future citizens, helping them become individuals who can understand, critically reflect, and creatively influence the technological world (Ge et al., 2015). In this approach, the teachers' role is to direct pupils through an open-ended problem-solving and design process, promoting both the aspects of knowledge-building and competency in using technology as a tool for creativity and innovation (Kangas et al., 2013; Riikonen et al., 2020). Organising experimental hands-on tasks enables pupils' collaborative knowledge creation (Yrjönsuuri et al., 2019). Despite recent developments, in many countries, technology education has less defined status in curricula than for example mathematics or science, and the understanding of its identity as a subject area is still evolving (Morrison-Love, 2017).

In Finland, technology education is a multidisciplinary and cross-curricular learning entity. Its organisation is based on team teaching where two or more teachers collaborate in planning, teaching and evaluation (e.g., Alsarawi, 2019; Pratt et al., 2017; Takala & Uusitalo-Malmivaara, 2012). Because co-planning forms the basis for the next phases of team teaching, it may be regarded as the most critical stage of technology education. In that stage, teachers often agree on the learning goals, share ideas on teaching and learning, explore each other's disciplinary perspectives, and negotiate between various possible teaching methods and practices suitable for implementation and assessment (Pratt et al., 2017; Udvari-Solner, 1996; Yinger, 1980). In the context of technology education, the planning stage often requires an understanding of technology and its integration with other disciplines (Bell, 2016; Jones & Moreland, 2004), which may be lacking from some individual teachers (El-Deghaidy & Mansour, 2015; Stein et al., 2001). Further, teachers may lack prior experience of facilitating open-ended problem-solving processes (Antink-Meyer & Meyer, 2016), which are integral to multidisciplinary technology education (Kangas et al., 2013; Riikonen et al., 2020). Even experienced teachers from different disciplinary backgrounds may have diverse expertise and ideas about the purpose and contents of technology education (Fahrman et al., 2019). Although multidisciplinary negotiation is challenging, it is crucial for constructing a shared framework for technology education (see Baker & Däumer, 2015; Rytivaara et al., 2019).

In addition to expertise in technology, teachers' actions in planning of technology education can be affected by self-efficacy, which refers to teachers' beliefs about their own expertise and ability to plan, teach, and evaluate activities for their pupils (see Bandura, 2012; Skaalvik &

Skaalvik, 2010). Self-efficacy is related to a self-perception of expertise that is different from teachers' actual expertise, but these beliefs influence teachers' decisions on how they apply their expertise (Tschannen-Moran et al., 1998). Teachers' self-efficacy in technology education comes from the sources of teacher education in technology, teachers' experience, and their own interest in technology education (Nordlöf et al., 2019). A previous Swedish study shows that teachers with subject-specific education in technology have higher self-efficacy than teachers without such training (Hartell et al., 2015). The continuous support for teachers is especially highlighted in a context, where technology education covers a broad subject area, because teachers can have a high self-efficacy in certain aspects of the domain and a low self-efficacy in some other areas (Nordlöf et al., 2019). While it is known that teachers' collaboration can strengthen their perceived self-efficacy, there is only a little qualitative understanding in how teachers perceive support from colleagues in planning (Chong & Kong, 2012).

Social support in the co-planning of multidisciplinary technology education

The ability to leverage the benefits of team teaching depends on support received from colleagues (Morelock et al., 2010; Scruggs et al., 2007), such as the degree to which individual teachers' disciplinary knowledge is available to others (Baker-Doyle & Yoon, 2011). Social support refers to the assistance received from others when dealing with the challenges of a certain environment (Thoits, 1986). The match between the support needed and support provided by others results in overcoming the challenges—but only if the support provided by others is perceived by the recipient (Haber et al., 2007). Thus, the actual support provided by the environment and perceived availability of the support should be examined as separate (Barrera, 1986). Based on the theories by Cobb (1976) and House (1981), Väisänen et al. (2016) distinguished three forms of social support: emotional, instrumental, and informational.

Emotional support refers to mental encouragement, and it provokes feelings of being trusted, respected, and valued (Cobb, 1976; House, 1981). In addition, emotional support may strengthen the individual experience of belonging to a certain network (Cobb, 1976), such as a group of technology educators. Emotional support has been considered the most important form of social support because of its stress-relieving functions (House, 1981). Accordingly, it has been suggested that the teacher community is a key factor in organising STEAM education because it enables teachers to share values and mutually commit to sharing goals and working together (Jho et al., 2016). Instrumental support refers to the practical assistance directed at managing a certain task (House, 1981; Mathieu et al., 2019). Based on Väisänen et al. (2016), instrumental support behaviours in teaching can be related to, for example, time, labour, or materials. In technology education, colleagues may support the planning of creative problem-solving activities. Sometimes, instrumental support functions can be embedded in other forms of social support if they together serve to solve a particular problem (House, 1981). For example, a teacher may need support in solving a technology-related problem in teaching. If colleagues provide emotional support by encouraging a teacher in problem-solving, emotional support can also be perceived to have an instrumental function. As defined by House (1981) and Väisänen et al. (2016), informational support includes two functions: information and appraisal. Informational support refers to receiving information that improves an individual's ability to cope with problems related to a certain environment (House, 1981). Väisänen et al. (2016) remark that often this kind of information is expected from an experienced person who has expertise in a particular area. For example, teachers can get information from their colleagues about the technological platforms that support them in planning technology education activities. In addition, informational support aids in appraisal, which means offering information relevant for self-evaluation (House, 1981). Feedback from others can be utilised for evaluating an individual (House, 1981), including their actions as a technology educator.

Previous research in education has applied the theory of social support mainly in relation to teachers' well-being. Perceived social support has been shown to decrease teachers' risk for emotional exhaustion and burnout (Greenglass et al., 1997; Kinman et al., 2011; Russell et al., 1987), contributing to improved professional efficacy (Kahn et al., 2006), job satisfaction, and motivation (Schonfeld, 2001). Perceived lack of social support has been connected to burnout (Brouwers et al., 2001; Burke et al., 1996; Cheuk & Wong, 1995), emotional exhaustion, and cynicism (Kahn et al., 2006). Although the forms of social support, and their contribution to teachers' well-being at work have been acknowledged, the body of knowledge on their benefits for co-planning of multidisciplinary technology education is limited.

Methods

Methodological approach

In this study, a qualitative research approach was chosen to create a comprehensive understanding of the social support involved in the teachers' experiences in the co-planning of multidisciplinary technology education. The study follows a constructivist research paradigm that includes a relativist assumption of reality as socially constructed and context-dependent (see, e.g., Mackenzie & Knipe, 2006). The results of this research are constructed from the meanings and interpretations that the teachers gave to their experiences in the specific interview situations. The results do not represent the general situation in Finland or cannot be applied in other contexts as such. However, the results provide insight into the unique experiences in co-planning of the in-service teachers who participated in this study.

Research context

Qualification as a teacher in Finland requires a completed master's degree, which requires five years of study in a university. Finland has a long tradition of research-based teacher education, which prepares teachers for being able to develop evidence-based practices for teaching and learning (Toom et al., 2010). However, the student teachers are not prepared for multidisciplinary technology education during their university studies, and there is no institutional professional education for in-service teachers in technology education. Technology education as an independent academic discipline was established in Finnish universities in 2018, as the first professors were recruited in the field. Before, the academic research in technology education had been integrated into the subject-specific pedagogical research of the STEAM fields. To enhance professional learning and development throughout the careers, the Finnish Ministry of Education and Culture promotes continuous learning programs as a part of the basic functions of universities.

This study is situated in the context of a technology education program piloted by two Finnish universities in 2019–2020. The program is targeted at student teachers and in-service teachers who are interested in technology education and who work at the primary, secondary, and general upper secondary levels. The aim is to encourage participants to inspire their pupils to learn about technology and develop the quality of technology education in their own work communities. The program applies the idea of multidisciplinary technology education, including three modules of five ETCS (European Credit and Accumulation System) each. During program participation, in-service teachers and student teachers organise team teaching experiments on multidisciplinary technology education in their own schools. Pedagogical and technological mentoring is offered to participants to support them with the experiments. The first module of the program introduces the participants to various innovative solutions for organising multidisciplinary technology education at different levels of education. The focus of the module is on supporting the co-planning of the participants' experiments. The module includes an introductory lecture about multidisciplinary technology education, teaching case examples, excursions, technology workshops, a reflection workshop, and a common 'shark tank' event, where the teams present their experimentation plans at the end of the module. For advancing reflection, the participants write learning logs by answering some supportive open-ended questions about their learning experiences. In the second module, attention is paid to the theme of team teaching in multidisciplinary technology education. The main theme of the third module is 'developer teachers' in the local school community.

Participants

The participants of this study were 11 in-service teachers from six teacher teams. The participants represented teams of two to seven teachers; most common team size was two teachers. The teachers were committed to the team teaching as a long-term collaboration. They co-planned teaching experimentations in multidisciplinary technology education, of which they were aiming to teach and evaluate together. The teachers worked at the primary, secondary, and general upper secondary levels in five different schools of 400—1000 pupils in Southern Finland. Three of the schools offered teaching at the primary and secondary levels, one school offered teaching only for the general upper secondary level, and one school had offering at all the levels of primary, secondary, and general upper secondary education. Two out of the six teacher teams planned technology education for primary school pupils, three teams planned teaching for secondary school pupils, and one teacher team had chosen general upper secondary school pupils as a target group. The teacher teams organised the co-planning in their own schools and the co-planning process was facilitated in the meetings of the technology education program.

The main criterion for selecting the participants was their background as experienced teachers. Most of them had previous experience both in technology education and working in multidisciplinary teacher teams. The length of the teachers' careers at the time of the data collection varied between six and 30 years. The teachers were qualified in a wide variety of school subjects, including mathematics, physics, chemistry, music, information and communications technology, and arts and crafts. Eight of the participants worked as subject teachers with one or more school subjects. Three participants were class teachers. In Finland, a class teacher can teach all primary-level subjects in their own class. One of the teachers had a leading role in the school community. The gender was close to an even distribution—there were five male and six female participants. The participants were given pseudonyms in the analysis.

Data collection

The qualitative research interview was applied as a data collection method for producing situated knowledge of teachers' experiences in co-planning (see, e.g., Qu & Dumay, 2011). The interview invitation was introduced in-person to all the 17 in-service teachers, who were attending the first module of the technology education program organised in fall 2019. Because the chosen research population of the in-service teachers in the technology education program was relatively small, more specific sampling criteria were not applied. Although all teachers expressed interest in participating in the study, six of them dropped out before the interviews. At the end of the module, the first author organised six in-depth group interviews with the 11 volunteering participants during 2019 and 2020. The first author was already familiar with the teachers and had an overall picture of the teaching experimentations that the teachers were planning, because she contributed in organising the technology education program. However, the first author did not participate in the co-planning activities that the teacher teams carried out. Before data collection, the participants were given explicit oral and written information about the research. Written consent for research participation was collected from the participants and no compensation was offered. The participants were aware that participation in the interviews did not affect the completion of the first module of the technology education program. They were informed of the possibility to cancel their participation at any stage of the study.

The semi-structured interviews focused on the teaching experimentation plans that the teachers had made in teams during the first module of the technology education program. The interview scheme (see Appendix 1) consisted of five sections. The sections were related to the context of co-planning, defining the experimentation idea, evaluation of the experimentation, external resources utilised during the co-planning, and further plans of how the teacher teams would like to continue with their experimentations. The interview scheme was tested in two pilot interviews before the actual data collection.

The interviewer gave the teacher teams freedom to choose the suitable time and place for their interviews to ensure easiness and convenience of the participation. Five teams were interviewed either in a quiet meeting room or in an empty classroom at their own workplaces. One teacher team chose a meeting room at the university as the place for their interview. The interviewer asked all the questions included in the interview scheme from the participants with an exception that a question was skipped if all the participants in the interview situation already clearly answered it. Occasionally, the interviewer asked additional open questions to encourage the participants to describe their experiences in a more detailed level, for example 'would you like to tell more about this' or 'could you give an example'. The interviewer paid special attention to the distribution of the statements, encouraging every participant to answer the questions. In two of the six interviews, the entire teacher team was not present. Especially in these interviews, the interviewer asked the participants to focus only on their own experiences, not on the perspective of their colleagues. The interviews were carried out in Finnish, each lasting from 50 to 110 minutes. The resulting 452 minutes of interview data were transcribed verbatim. The interview transcriptions were not possible to disclose in any public repository because of the confidentiality of the content.

Analysis

To create a condensed description of social support involved in the teachers' experiences in co-planning, the transcribed interviews were analysed following the principles of a qualitative content analysis (Elo & Kyngäs, 2008; Graneheim & Lundman, 2004). The analysis was carried out in the three stages presented in Figure 1.

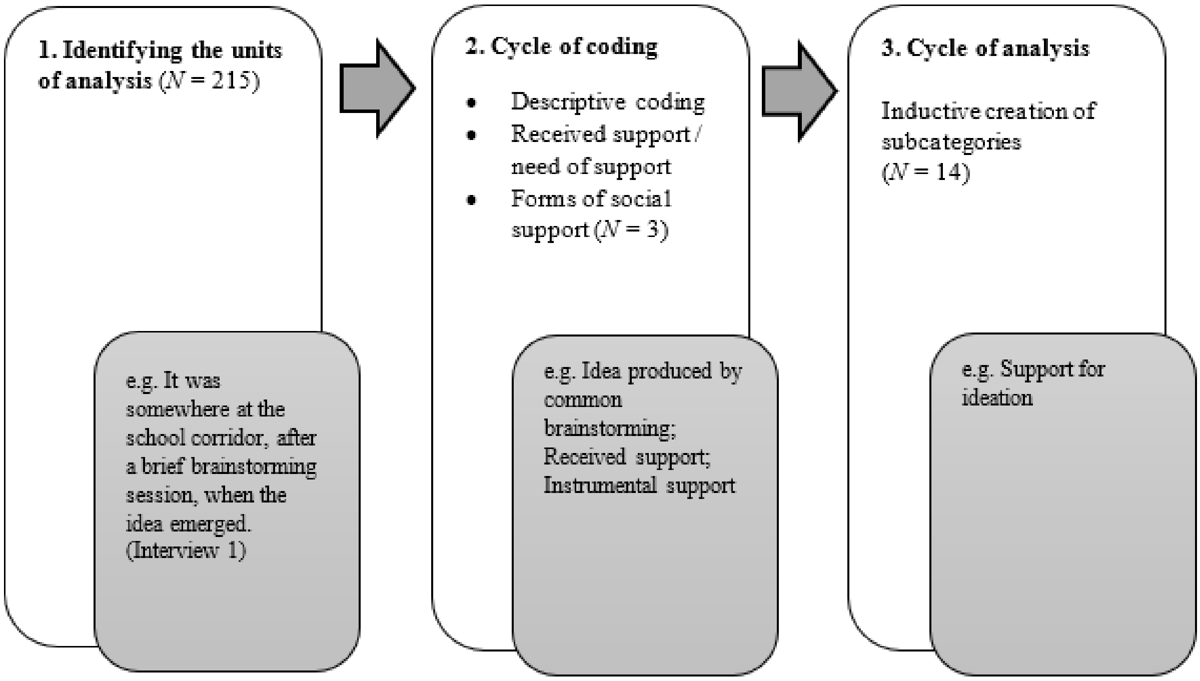

Figure 1. Analysis process.

The first stage of the analysis began by reading through the interview transcriptions several times to get an overall picture of their content. After familiarising with the data, the units of analysis were identified (N = 215). A unit of analysis was a coherent fragment of data that described social support or the need for it, here stemming from team teaching at the school environment. Each unit of analysis included statements from one or two teachers. Concerning the study aim, the focus of the analysis was decided to keep at the level of teacher teams instead of separating single teachers' responses from the interviews. Descriptions of the collaboration in the technology education program were excluded from the research in the phase of identifying the units of analysis.

The second stage of the analysis was a cycle of coding, where three simultaneous codes were assigned to each unit of analysis. First, a descriptive code for each unit of analysis was created by condensing its content briefly. Second, each unit of analysis was coded in terms of received support or need of support. As these two categories were not mutually exclusive, ten units of analysis belonged to both categories. Third, based on the theory of social support (Cobb, 1976; House, 1981) the units of analysis were coded into three main categories of emotional, instrumental, and informational support. The emotional support category contained mental resources, such as enthusiasm, encouragement, and sharing interests. The instrumental support category included the practicalities that directly supported teachers in their co-planning activities, such as shared ideation sessions, conversations, meetings, and sharing responsibilities over teaching. The informational support category covered information that supported teachers' actions as technology educators, such as the expertise and feedback offered by other teachers on technological or pedagogical aspects. Noting the overlapping nature of the different forms of social support (see House, 1981), there was a subtle overlap between the main categories created. Out of the total of 215 units of analysis, eight units were placed under two main categories, and one unit was related to all three main categories. To ensure the robustness of the first cycle of coding, the first and the second author coded one interview together by discussing their interpretations. Hereafter, the first author coded the rest of the data, and the second author worked as a second coder for three of the interviews.

The third stage included a cycle of analysis, in which the categorisation of social support was complemented with inductively created subcategories. At this stage, the units of analysis were clustered inductively based on their shared meanings by utilizing the descriptive codes already created at the previous stage. The first author carried out a tentative clustering, which was elaborated together with the second author. To raise the abstraction level of the analysis, the clusters were compared and grouped into preliminary subcategories. The authors continued categorisation until they both agreed that any new clusters and subcategories were not emerging from the data; this was deemed as a point of theoretical saturation of the analysis (see Corbin & Strauss, 2008). The resulting final coding scheme included three main categories and a total of 14 subcategories. Each main category included from three to seven subcategories, where each subcategory consisted from one to nine clusters of data. The 14 subcategories covered all 215 units of analysis of the data, and each of the subcategories represented data from two to six teacher teams. Most commonly, a subcategory consisted of the experiences of five teacher teams, average being 4.7 teacher teams per subcategory. Again, some overlap between the categories was found. Under the main category of instrumental support, five units of analysis were located under two subcategories. The main category of emotional support included two units of analysis located under two subcategories.

Results

Overview of the results

This study examined the social support involved in the co-planning of multidisciplinary technology education. The overview of social support involved in the teachers' experiences in co-planning is presented in Table 1. In the following subsections, the content of the categories is reported in a more detailed level from two perspectives: received support and needs for support.

Table 1. Social support in the co-planning of multidisciplinary technology education.

Forms of social support	Experiences in co-planning
Instrumental	Support for ideation
	Aid for the planning of teaching
	Flexibility in the guidance of pupils
	Cooperation in teaching
	More opportunities for implementation
	Pedagogical leadership
	Sharing responsibility for teaching
Informational	Technological expertise
	Pedagogical development expertise
	Knowledge of pupils
Emotional	Enthusiasm
	Encouragement
	Sharing interests
	Sense of community

Social support received in the co-planning of multidisciplinary technology education

The first research question concerned the social support received by the teachers in the co-planning of multidisciplinary technology education. In the teachers' experiences of receiving support, the emphasis was on instrumental support, which can aid a teacher team in their co-planning activities of multidisciplinary technology education. In addition to instrumental support, the teachers' experiences covered emotional support, which aids a teacher team in working for a common goal, and informational support, which includes information that supports teachers' actions as technology educators. The received social support in co-planning is presented in Table 2.

Table 2. Received social support in co-planning.

Forms of social support	Received support in co-planning
Instrumental	Support for ideation
	Aid for the planning of teaching
	Flexibility in the guidance of pupils
	More opportunities for implementation
	Cooperation in teaching
	Sharing responsibility for teaching
Emotional	Enthusiasm
	Encouragement
	Sharing interests
	Sense of community
Informational	Technological expertise
	Pedagogical development expertise
	Knowledge of pupils

Instrumental support

Most experiences of receiving instrumental support were related to *ideation*. Cooperation was considered as a way of improving the quality and increasing the number of potential ideas for teaching. Ideation was described as a shared effort in which every group member took part, usually by sharing their ideas in discussions. Cooperation made it easier to choose and define ideas for further development. In the following quotation, the importance of cooperation is highlighted in producing good ideas for the experiment:

> *When we made the plan together, as there were many of us present, the conversation started to find its course, and good ideas were produced in the joint discussion. (Interview 3)*

Cooperation worked as an *aid for the planning of teaching*, which consisted of support for overall implementation; choosing a target group of pupils, pedagogical approaches, and the theoretical framework for technology education, planning materials, and exercises; perceiving curriculum relations, utilisation of already existing contents and resources; choosing the applicable technology; planning the schedule; and planning excursions. The group discussions were viewed as a venue for sharing ideas about the concrete implementation of the experiment, as pointed out in the following quotation:

> *For a long time, we wondered what could be the first project to start with. It does not mean that this will be the only project and that we will continue with this forever. Actually, we have many visions that we could execute at some point. This one we considered as concrete and it was already implemented, so it will certainly succeed. (Interview 5)*

Working in a team was perceived to *add flexibility in the guidance of pupils*. Most of these experiences were related to sharing the guidance of pupils with others. Other teachers' and student teachers' presence in the classroom was seen as reducing a single teacher's workload by either co-teaching in the same classroom or dividing the groups of pupils into parts. In some experiences, flexibility in the guidance of pupils was also portrayed in terms of adaptive and dynamic guidance better meeting the pupils' needs. Cooperation enabled *more opportunities for implementation*. Opportunities to tie lessons of different subjects together made it possible to get in more time for technology education. There were also opportunities to widen the focus of the experiment by applying new tools and techniques and to get support for technology and building.

The presence of teachers from different areas of expertise was seen as a mean to promote *cooperation in teaching* between school subjects. Everyday encounters and previous experiences of working in common projects made the cooperation easier. The possibility of choosing a team based on each teacher's area of expertise was highlighted as important. *Sharing responsibility for teaching* lightened the teachers' workload. In a teacher team, every member had their own areas of responsibility.

Emotional support

In the experiences of receiving emotional support, *enthusiasm* typically emerged in the group conversations. Good feelings, positive expectations, and satisfaction with successful teamwork were shared during the co-planning process, as the following quotation demonstrates:

> *The ideas come from both of us and together we have […]. In a sense, it is nice that you cannot know whom the idea originally came from. One always inspires another. (Interview 5)*

Perceptions of *encouragement* were mainly related to the beginning of planning the experiment. The teachers were either encouraged to join the experiment by their colleagues and school community, or they encouraged their colleagues or student teachers to join their team. The following quotation points out how colleagues encouraged the teachers to join the experiment:

> *Well, my colleagues encouraged me to join [the experiment]. I was not under pressure; the information just was there. And then [a colleague] mentioned that this is a good thing, like, come along. And I started to think that okay, I could go, why not. (Interview 6)*

Sharing interests with other members of the team supported the teachers' work, especially in the phase of planning the experiment. Gathering around a common interest enabled well-functioning collaboration. As a form of social support, *sense of community* included experiences of fellowship because the teachers were in close collaboration or were friends outside of the workplace. Trust in colleagues and trust in the school community were experienced. Feelings of not being alone were seen as essential in the implementation of the experiment.

Informational support

In the experiences of receiving informational support, *technological expertise* was emphasised; this was related to both technological tools and platforms and the ways of applying them in teaching. For example, other teachers' and student teachers' knowledge of augmented reality, programming, and using a vinyl cutter were mentioned. Support for concrete building in implementing the project ideas was also recognised. The following quotation highlights the benefits of the teachers' combined technological expertise when it comes to enhancing pupils' learning:

> *It is the beauty and the difficulty of this kind of stuff that they [pupils] may come up with very new and surprising things that they would like to test, and I do not master all the techniques, and then I can think if [a colleague] could instruct, or if [another colleague] could instruct, and luckily there are several teachers involved. And, I consider it as very motivating for the pupils on that level to get actual freedom instead of always giving them the same task. (Interview 1)*

Pedagogical development expertise was related to implementing a multidisciplinary curriculum. The perceptions considered versatile subject didactical expertise because each teacher in a team brought knowledge of how the project ideas on technology education can be related to the teaching of their school subject. Working in a diverse team supported achieving a better understanding of a project as a whole. Sharing knowledge supported the formation of the boundaries for applying technology in the project, as described in the following quotation:

> *Of course, another [teacher] looks at [the experimentation plan] from their own perspective, whether it is realistic or not. I am sure that I have come up with such ideas that are impossible to build—according to the craft teacher. (Interview 5)*

Knowledge of pupils was formed by sharing practical experiences of teaching a target class. Conversations about pupils were seen as being overall supportive. In addition, knowledge that other teachers brought up in pupils' level of skills in their teaching subject supported flexible guidance in co-teaching situations.

Needs for social support in the co-planning of multidisciplinary technology education

The second research question concerned the social support needs of the teachers in the co-planning of multidisciplinary technology education. The social support needs in co-planning are presented in Table 3.

Table 3. Social support needs in co-planning.

Forms of social support	Needs in co-planning
Instrumental	Pedagogical leadership
	Cooperation in teaching
	Flexibility in the guidance of pupils
Informational	Pedagogical development expertise
	Technological expertise
Emotional	Sharing interests
	Encouragement

Pedagogical leadership was experienced as a major need of instrumental support by the teachers. These descriptions were related to joint decision-making during the co-planning process concerning timetables, group division, evaluation methods, the work division among teachers, aims of the experiment, and funding. In the following quotation, the need for a person leading the planning process is stressed:

> *I think that we should gather together with the whole team—we should agree on a person who is responsible for this and takes care of the meetings and that we do something. (Interview 5)*

The need for *cooperation in teaching* considered promoting multidisciplinary team teaching by inviting more colleagues from different backgrounds to join the experiment. *Flexibility in the guidance of pupils* was seen as essential because the planned activities often required more than one teacher to be successfully implemented.

The need for informational support included *pedagogical development expertise* and *technological expertise*. Pedagogical development expertise was needed for multidisciplinary curriculum implementation and the demand for renewing teaching. Implementing the new multidisciplinary curriculum was viewed as challenging, as described in the following quotation:

> *According to our curriculum, these multidisciplinary [topics] should be present in every school subject. Well, it is a bit problematic. - - We cannot try to push them all into the same project for getting all the multidisciplinary [objectives] to match. (Interview 6)*

The need for technological expertise was related to the technologies used during the implementation of the experiment. In one part of the perceptions, a specific need for expertise with a certain piece of technology was described, for example, in augmented reality–related technologies. In the other part of the perceptions, only a general need for expertise in technology was recognised.

The need for emotional support was rarely identified. The forms of emotional support that were called were *sharing interests* with colleagues who were truly willing to participate in the experiment and getting *encouragement* for experiments from principals and school district managers.

Discussion

Results in light of the previous literature

The aim of this study was to explore what kind of support is involved in one of the most critical stages of team teaching: co-planning. While previous studies have widely agreed on the benefits of multidisciplinary team teaching in balancing out teachers' individual differences in their professional competence of technology education (Kafyulilo et al., 2016; see also Salonen & Savander-Ranne, 2015; Voogt et al., 2016), the ability to leverage it depends on the availability of social support from colleagues (see Morelock et al., 2010; Scruggs et al., 2007). However, previous research on how teachers experience social support in multidisciplinary team teaching is lacking. This study sets the ground for leveraging social support in the context of multidisciplinary technology education.

The primary, secondary, and general upper secondary level teachers' experiences of co-planning of multidisciplinary technology education involved three forms of social support: instrumental, informational, and emotional support. In the teachers' experiences of social support, new ideas, tools, and methods for implementing technology education in a classroom were emphasised. This instrumental form of support involved in co-planning in multidisciplinary teams enriched the pool of possibilities for implementing technology education in the classroom beyond what an individual teacher could have come up with alone. As teachers may have limited, varying, and even conflicting views on the aims and methods of technology education (Kokko et al., 2020), negotiation on the joint focus on technology education is a prerequisite for successful multidisciplinary co-teaching (cf. Lehtonen et al., 2017). This study supplements previous research by highlighting the importance of multidisciplinary negotiations as an enabler for developing more versatile solutions for technology education.

Although teachers' instrumental social support provided new ideas for the implementation, they struggled to organise the decision-making processes without anyone having a formal leadership status over the others. Consequently, more support for organising and coordinating the co-planning process among teachers from different disciplines was called for. While previous studies have highlighted the importance of establishing common structures and routines for co-planning (Takala & Uusitalo-Malmivaara, 2012; Alsarawi, 2019; Pratt et al., 2017), the focus has often been on the role of formal school-level leadership in creating and maintaining a collaborative culture (Haapaniemi et al., 2020; Margot & Kettler, 2019). The findings of this study highlight the importance of informal team-level leadership as a critical form of instrumental support for the co-planning of technology education.

According to this study, teachers can leverage each other as a source of informational support related to technological expertise, such as selecting and applying suitable technological tools and platforms for the students. In addition to technological expertise, technology education requires expertise in integrating technological perspectives across disciplines (Bell, 2016; Jones & Moreland, 2004). Consequently, teachers called for more pedagogical development expertise to supplement the technological expertise of the multidisciplinary teaching team. Pedagogical support was especially needed in relation to fulfilling the multidisciplinary curricula requirements. Sharing pedagogical development expertise clarified the objectives and boundaries of the joint technology education offering; it also enabled the evaluation and testing of ideas from the perspective of different disciplines, which is referred to as 'appraisal' in the social support theory (House, 1981).

This study reveals that while multidisciplinary team teaching in the planning stage of a teaching process serves as a source of enthusiasm and encouragement, more emotional support was rarely called for during the co-planning process. Previous studies have identified the role of emotional support, such as sharing values and mutual commitment, as the most important resources for the implementation of STEAM education (Jho et al., 2016). Even though the teachers did not rely on each other for emotional support in the co-planning stage, the importance of emotional support is likely to be highlighted in the co-teaching stage. Such support is especially relevant when the degree of interaction with pupils increases and possible personal conflicts surface (see, e.g., Näring et al., 2012; Yin & Lee, 2012). In the meanwhile, the instrumental and informational forms of social support are highlighted as critical for balancing out teachers' individual differences in their professional competence of multidisciplinary technology education (see, e.g. Fahrman et al., 2019; Nordlöf et al., 2019).

Practical implications

As social support nurtures the co-planning of multidisciplinary technology education, in-service teachers should have more opportunities for collaboration in planning at the primary, secondary, and general upper secondary levels. For student teachers, teacher education should provide more opportunities to practice team teaching with their peers during training (see Weiss et al., 2015). In schools, formal pedagogical leadership should be applied to support the establishment of a collaborative culture among teachers (Haapaniemi et al., 2020; Margot & Kettler, 2019). In addition, informal pedagogical leadership is needed to ensure successful decision-making in co-planning. A possible solution could be developing ways to distribute leadership between teacher teams and the formal head of a school (see Blinkhorst et al., 2018; DeMatthews, 2014).

Limitations and further research ideas

The findings of this study reflect the views of a limited group of participants and are tied to the extent to which they recognise receiving and needing social support (see Haber et al., 2007). It is possible that the participants did not recognise all forms of social support involved in their co-planning efforts. It is also possible that they did not feel comfortable sharing the negative experiences of their team teaching in the group interview setting. Inductive method was applied in the analysis of the interview data. Although inductive reasoning gave the researchers purposeful direction for analysis, it should be noted that this approach draws on generalised conclusions. Because most of the participants had previous experience in co-planning of multidisciplinary technology education, the results may not apply to novice technology educators. In addition, the applicability of the results to tertiary-level education should be further explored.

The theoretical framework of this study provides a basis for further research on social support in team teaching in multidisciplinary technology education, including the phases of co-teaching and co-evaluation. Furthermore, the framework could be applied to a broader range of technology educators covering, for example, student teachers and tertiary-level teachers. Further studies are needed to explore the quality and applicability of multidisciplinary technology education plans resulting from the co-planning phase of team teaching.

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Appendix 1. Interview scheme

1. The context of co-planning

- Please describe your thoughts and feelings regarding the joint technology education planning process.
- Even though I am familiar with your teaching experimentation plan, please explain the following in your own words:
    - What the experiment will be?
    - Who will be included into the experimentation?
    - Are the student teachers involved in your teaching experiment? How so?
    - Where will the experimentation be implemented?
    - How will you carry out the experimentation (materials, equipment)?
    - Does technology have any role in your teaching experiment? What kind of role does it have?
- How did the planning process begin?
    - What kind of things did you discuss about when starting the planning process?
    - What kind of choices did you have to make in the beginning of the planning process?
- What kind of aspects influenced the planning process?
- What will the target group of your teaching experiment be?
    - Did the target group somehow have any impact on the planning process?
- Why did you participate in this teaching experiment?
- Because you as teachers represent different fields, did it somehow have an impact on the planning process?

2. Defining the experimentation idea

- How did you come up with an idea?
    - Why did you choose this idea?
    - Did you know straight away that you will choose this idea, or did you have some other options also?
- What are the pupils supposed to learn during the experiment?
    - What kind of learning aims are included?
    - Why did you choose these learning aims?
- As you had come up with an idea and defined the aims for your teaching experiment, how did you continue?

3. Evaluation

- How would you evaluate the ideas in practice?
- If you implemented the teaching experiment, how could you evaluate it?

- Do you see any constraints related to your plan?
    - *Refine, if needed*: Constraints mean something that especially needs to be considered when starting to implement the plan. For instance, the applicability of an idea for some specific school grades.

4. External resources

- What kind of information did you exploit during the planning process?
- Did you learn something new as you made the plan?
- If you implemented the plan now with this group of teachers, would you need to acquire some more expertise?
    - Where could you get the expertise needed?

5. Further plans

- Are you satisfied with your teaching experimentation plan? Why?
- Do you recognise any development points from your plan? What kind of?
- How could you further develop the plan?
- Would you like to complement your answers?

Industry 4.0 Competencies as the Core of Online Engineering Laboratories.

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Abstract
Online laboratories are widely used in higher engineering education and due to the COVID-19 pandemic, they have taken on an even greater relevance. At Tecnologico de Monterrey, Mexico, well-established techniques such as Problem-Based Learning (PBL), Project-Oriented Learning (POL) and Research-Based Learning (RBL) have been implemented over the years, and over the past year, have been successfully incorporated into the students' learning process within online and remote laboratories. Nevertheless, these learning techniques do not include an element which is crucial in today's industrialized world: Industry 4.0 competencies. Therefore, this work aims to describe a pedagogical approach in which the development of Industry based competencies complements the aforementioned learning techniques. The use and creation of virtual environments and products is merged with the understanding of fundamental engineering concepts. Further, a measurement of the students' perceived self-efficacy related to this pedagogical approach is carried out, focusing on the physiological states and mastery experiences of the students. An analysis of its results is presented as well as a discussion on these findings, coupled with the perspectives from different key stakeholders on the importance of the educational institutions' involvement in developing Industry 4.0 competencies in engineering students. Finally, comments regarding additional factors which play a role in the educational process, but were not studied at this time, as well as additional areas of interest are given.

Key Words
Educational Innovation; Higher Education; Digitalization; Online laboratories; Industry 4.0; Engineering Education.

Introduction
Laboratories are widely used in higher engineering education due to the necessity of not only learning, but implementing engineering concepts as part of the pedagogical process. Several strategies have been implemented since the early 2000's to provide web-based, hands-on approaches thanks to the possibility of accessing facilities remotely. Such approaches maintain the traditional objectives of on-site facilities, such as demonstrating analytic concepts, exposing students to a broad range of issues and potential problems, and comparing theoretical and real-world results (Heradio et al., 2016; Potkonjak et al., 2016). Thus, these online laboratories,

or experimentation environments, are often grouped in the following manner (Gomes & Bogosyan, 2009; Heradio et al., 2016; Potkonjak et al., 2016):

- Physical laboratories, where students are present in facilities equipped with specialized devices, either physical, virtual, or even a mixture of both, and these are used to develop the aforementioned hands-on experiences.
- Remote laboratories, where a student is able to exploit existing infrastructure using an Internet connection, usually visualizing real-time events through webcams.
- Virtual laboratories, which mainly use simulation packages to deliver the practical component of engineering education. The software is normally based on mathematical models of varying complexities and allows for a wide range of experiences, without the need of costly experiments.

Moreover, these approaches have been used in several disciplines with varying results, and lately, their impact generated is being studied with increasing frequency. For example, Gravier et al. (2012) discuss a collaborative online laboratory strategy and its association with both the tutor's pedagogical objectives, and the management of the group of participating students. May (2020) explores new technological trends, describes how online laboratories can be cross-reality (XR) spaces in education as different realities are merged, for example, through the use of the real hands-on world in physical labs and the virtual one through simulated environments.

Additionally, online laboratories have taken on great relevance due to the COVID-19 pandemic which forced educational institutions around the world to make major changes in the teaching-learning system, thus accelerating their efforts in remote learning. For example, Lall & Singh (2020) present a study which attempts to understand the students' perspective, attitudes, and readiness about online classes. Daniel (2020) reflects on the guidance that teachers, institutional heads and officials need to have in order to address the COVID-19 educational challenges and Arnove (2020) argues that the COVID-19 crisis offers a unique chance to improve the educational systems from a socio-economic point of view.

According to the above, the use of remote and virtual tools brings about new challenges in the application of well-established learning techniques and are being increasingly studied. Indeed, Zacharia et al. (2015) identify specific types of guidance required to support student use of online laboratories, in the context of Inquiry-Based Learning (IBL). On their side, Jara et al. (2012) present a synchronous approach of Collaborative Learning (CL) where practical experimentation is carried out in virtual and remote laboratories. Wuttke et al. (2010) explain how remote and virtual laboratories can support Problem-Based Learning (PBL) scenarios and Sucar et al. (2005) evaluate how virtual laboratories and tutors can help in the acceleration and improvement of the learning process using a Project-Oriented Learning (POL) strategy.

Even though mass-implementation of online engineering laboratories is relatively new, Tecnologico de Monterrey, Mexico, was among the first to successfully apply some of the above learning techniques when face-to-face sessions were replaced with online teaching due to COVID-19 pandemic. Nevertheless, studies of student self-efficacy within Tecnologico de Monterrey's online laboratories have not yet been conducted and, specifically, studies regarding the students' self-efficacy have not included an element which is crucial in today's industrialized world: Industry 4.0 competencies.

According to Bandura (1986), self-efficacy refers to an individuals' beliefs in their capabilities to organize and execute actions required to achieve a particular outcome. Furthermore, Bandura (1977, 1997) states that there are four main sources of efficacy beliefs: mastery experiences, vicarious experiences, social persuasion, and physiological states. Mastery experiences refer to personal performance accomplishments, that is, to the individuals' perceptions based on their own life experiences of success and failure. Vicarious experiences refer to the observation of other people's experiences. Social persuasion indicates how efficacy beliefs change according to positive or negative influences of other people or certain situations. Finally, physiological states are linked to how efficacy beliefs are affected by the reactions, such as anxiety or stress, to events that occur in a person's life.

Although there are several interesting studies of students' self-efficacy that involve engineering education, online laboratories, or even competence-based learning (Bartimote-Aufflick et al., 2015; Ponton et al., 2001; Marra et al., 2009; Kolil et al., 2020; & van Dinther et al., 2014), there are few works that address self-efficacy from the viewpoint of the skills that students need to learn in the context of the so-called Industry 4.0. In this way, Cropley (2020) highlights the importance of creativity-facilitating competencies, such as self-efficacy, to better face the challenges that Industry 4.0 brings into technology education.

The Fourth Industrial Revolution, also known as Industry 4.0, is a concept which emerged from the combination of emerging information and operation technologies with the aim of upgrading production systems into smart factories. Nowadays, this concept has been extrapolated outside of the shop floor. Bongomin et al. (2020) show how the use of technologies has impacted various sectors of society, such as consumer habits, health care, transport, finance, and human development. Thus, technologies and disciplines such as automation and control, data analytics, artificial intelligence, as well as the massive interconnection of systems and devices which can be monitored and controlled remotely, set a new framework of evolving requirements, skills, and competencies that need to be considered in education. In this way, examples of studies where Industry 4.0 and education have merged to form Education 4.0 are given. Motyl et al. (2017) discuss the skills and expertise that young engineers require to be ready for the Industry 4.0 framework; Benešová & Tupa (2017) present the requirements for education and qualifications that people need in jobs related to Industry 4.0; Siti Rashidah et al. (2019) identify skills that engineering graduates need to be qualified in manufacturing and construction systems of Industry 4.0. Grodotzki et al. (2018) describe the development of remote and virtual laboratories for engineering education with a focus on manufacturing technology related to Industry 4.0; Suhaimi et al. (2019) examine the impact of a computer architecture and organization course on students' learning based on the Education 4.0 framework; and Salah et al. (2019) show how students use virtual reality in a prominent concept of Industry 4.0: reconfigurable manufacturing systems.

Although the above shows that Industry 4.0 and its related concepts already play an important role in the teaching-learning process, it is also extremely relevant to know if students perceive that Education 4.0 is something positive within their professional training. Further, it is also of interest to know if they perceive that Industry 4.0 competencies aid them to achieve a good academic performance. Thus, measuring students' self-efficacy regarding Industry 4.0 competencies and their impact, is an important study which will likely help improve the learning techniques implemented in the online laboratories of Tecnologico de Monterrey. In this way, examples of studies on the students' self-efficacy using online laboratories are given by Nickerson et al. (2007), who propose a model for testing the relative effectiveness of engineering laboratories in education through on-site and online labs; Viegas et al. (2018) describe how the interaction with teachers has a significant influence, not only on the students' performance, but also on their perception of their learning process and the overall satisfaction with remote laboratories and Fabregas et al. (2011) perform an analysis of the impact of remote experimentation on the academic performance of students, and its influence on the quality of the learning process via an online control engineering laboratory.

Therefore, our work is focused on the following two aspects of students' self-efficacy:

- Physiological states; where students' efficacy beliefs were affected by the COVID-19 pandemic. In this sense, they feel that the absence of face-to-face and hands-on experiences in engineering laboratories has been detrimental to their learning.
- Mastery experiences; where students' self-efficacy can be improved by obtaining successful results in activities and tasks related to Industry 4.0.

With this in mind, this document attempts to answer the following research questions:

- How can we ensure that students develop a sense of fulfillment in their online learning process, considering that they appreciate the hands-on approach of traditional laboratories?
- Can we help students to maintain a sense of self-efficacy by implementing activities and tasks similar to those carried out in an Industry 4.0 position within the courses?

Thus, an analysis of the students' self-efficacy, perceived around the acquisition of knowledge and the development of competencies related to Industry 4.0, is performed. Such competencies are related to the use and development of virtual environments, and products, to interconnect real and virtual systems using existing infrastructure in Tecnologico de Monterrey. This is being done to prepare an engineering workforce capable of facing future challenges in an increasingly digitally-connected world.

The way in which Industry 4.0 competencies are being developed within the pedagogical method is described in the following section, showcasing examples of such approach. Later, in the results' section, the way in which the self-efficacy of the students was analyzed is shown by explaining the exit survey implemented throughout various engineering courses, regarding the use of online laboratories within the proposed framework. Finally, in the discussion and concluding remarks, the impact of this approach from the point of view of both students and teachers, exposing the perspective that engineering professionals have on the importance of the educational institutions involvement in developing Industry 4.0 competencies in engineering students, is discussed.

Industry 4.0 based learning

The current work was developed in the context originated by the lockdowns implemented after a state of pandemic emergency was established, related to the SARS-CoV-2 virus. Tecnologico de Monterrey, a private Mexican University, was among the first to switch to online classes prior to an official government mandate in order to protect their studentship and employees.

This was achieved through the use of Zoom Video Communications Inc. (2020) for online communications and Instructure Canvas, (n.d.) as the learning management system, coupled with a synergic use of simulation packages and online laboratories. Before the pandemic, students were able to interact with diverse engineering software, through academic licenses, as well as specialized automation hardware and other equipment at the university's facilities. After the lockdown, the computers, specialized automation hardware, and compatible devices were set up in a way that students could still use them remotely.

As known, Problem-Based Learning (PBL) is a teaching technique that uses real-world problems to promote learning in students by focusing on the process carried out to solve these problems (Wood, 2003). On the other hand, Project-Oriented Learning (POL) focuses on obtaining a final product over a certain period of time, without overly considering the development process (Moesby, 2005) and Research-Based Learning (RBL) is an approach that promotes and develops student competencies related to research practice as well as additional activities linked to research (Noguez & Neri, 2019).

As mentioned, the approach presented promotes the use of the existing infrastructure to allow the students to create and use virtual environments and products following the aforementioned learning strategies (i.e. PBL, POL, RBL) to boost their skillset and adapt it to the needs of Industry 4.0. Therefore, a review of existing practices to maintain the techniques' educational intent, while adapting them to the current needs and possibilities was required.

The mode of work affects the behavior of society (Bauer et al., 2015). Nowadays, the lifecycle of products and processes is shorter which means that production processes must now be flexible, robust, and low cost. Saturno et al. (2018) established that information technologies, such as telecommunications, cybersecurity, and databases have been integrated with operational technologies like sensors, actuators, controllers, and interfaces to establish the pillars of Industry 4.0 (i.e. industrial internet of things, big data, cloud computing, models and simulation, extended reality, among others).

The knowledgeable use of telecommunications, artificial intelligence, creation of virtual environments, and the interpretation of results obtained from simulations are some of the skills required in this new digital age (Bauer et al., 2015; Papanastasiou et al., 2019). To achieve the development of these competences, changes must be made in the content and teaching methods, where integrating industrial tools into the classroom is of the utmost importance. Leng et al. (2019) considers that the creation of a smart factory requires three main concepts: a digital twin (DT), internet of things (IoT), and cyber-physical systems (CPS). The exchange of data between devices through a communication protocol (i.e. IoT) allows us to generate a model that represents the behavior of these devices (i.e. DT). CPS refers to the interconnection between physical and virtual systems and their development represents one of the main Industry 4.0 competencies that students can develop to be prepared for the future. The successful implementation of a CPS is the result of a digital transformation deployment, a process which has several stages and components which can range from the computer-aided visualization of the system in question, to the remote manipulation and reconfiguration of an entire manufacturing process using virtual and augmented reality tools.

The pedagogical method presented attempts to implement many of the concepts described above to enhance the learning experience. Thus, to better understand the approach, the authors present the Digital transformation deployment diagram (Figure 1), which includes the key Industry 4.0 components that were implemented in the learning environments. Each stage of the deployment is assigned a specific color and will be used throughout the remainder of this text.

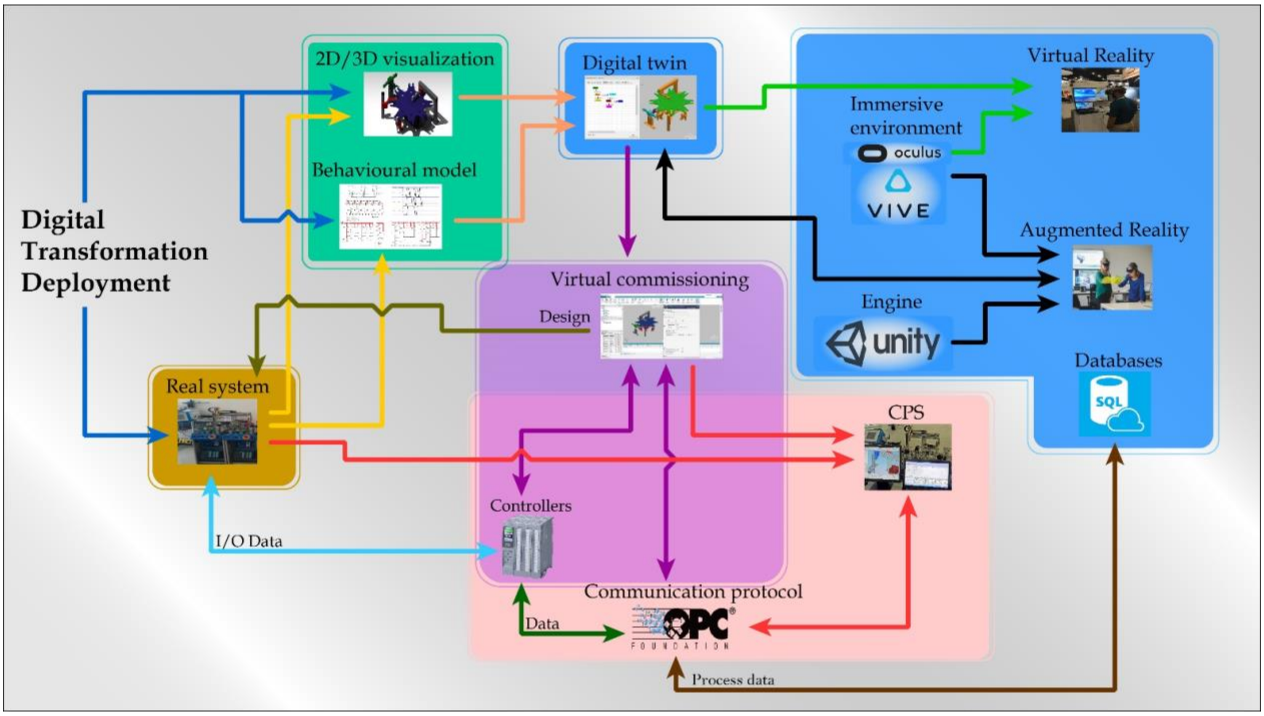


Figure 1. DTD diagram including the elements involved in each phase and associated flow of information. The logos included (i.e. OPC, Unity, VIVE, SQL) show some of the protocols or software used in certain stages.

For a better understanding of the stages and to simplify the transfer of knowledge between courses, these concepts were split into four cases according to the level of digitalization applied. A synthesized summary of the cases is presented in Figure 2 which shows how each stage is built on another as the interaction between physical and digital elements is tightened.

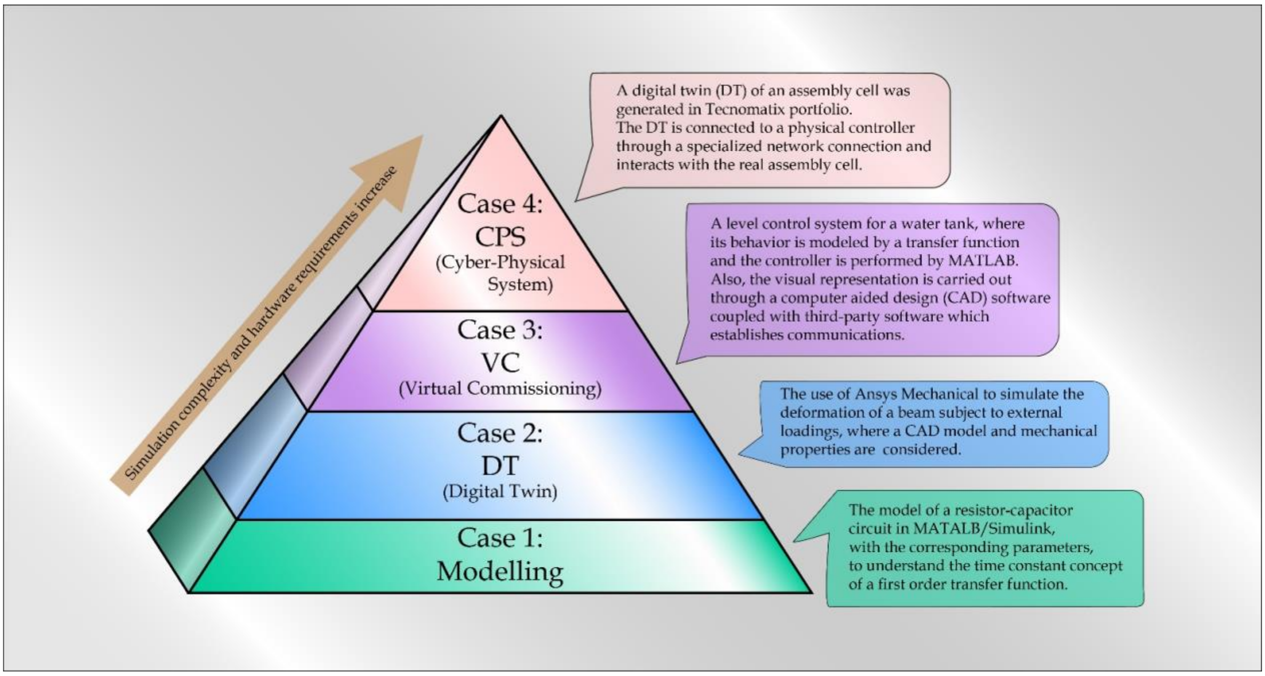


Figure 2. Synthesis of the proposed cases. The colors are associated with the stages of the DTD diagram (Figure 1).

Case 1: Modelling

Consists in the use of behavioral, logic, geometrical, or visual information to represent a physical phenomenon. This is the most generic use of traditional Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) tools such as Siemens NX, Mathworks Matlab/Simulink, Ansys Fluent, among many others.

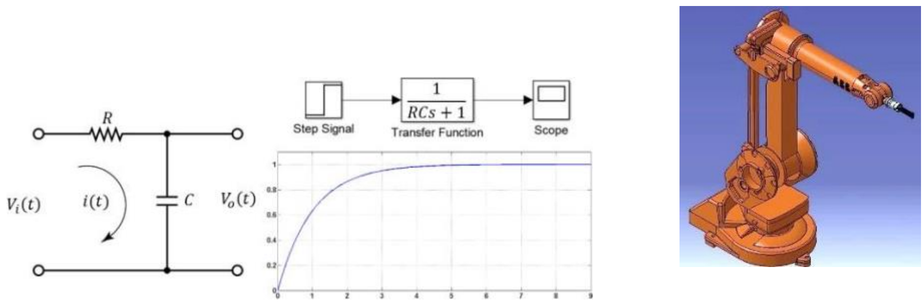


Figure 3. Examples developed by the authors throughout diverse courses, including a behavioral model (left) of an RC circuit (Matlab), and a CAD model (right) of an ABB IRB 1400 robotic arm (DS CATIA).

Case 2: Digital Twin (DT)

Requires both a visual representation and a behavioral model to be simulated. The visual representation reacts to a stimulus and generates a response according to the pre-defined behavior. A DT is a reliable representation of a physical phenomenon, which is often used to evaluate “what if…?” scenarios (Esqueda et al., 2020). This kind of representation is usually obtained within the same software but can also be achieved by linking different packages. For example, Siemens SIMIT can be used together with Matlab Simulink and other modules, in order to ensure that physical laws govern the behavior of the virtual prototype.

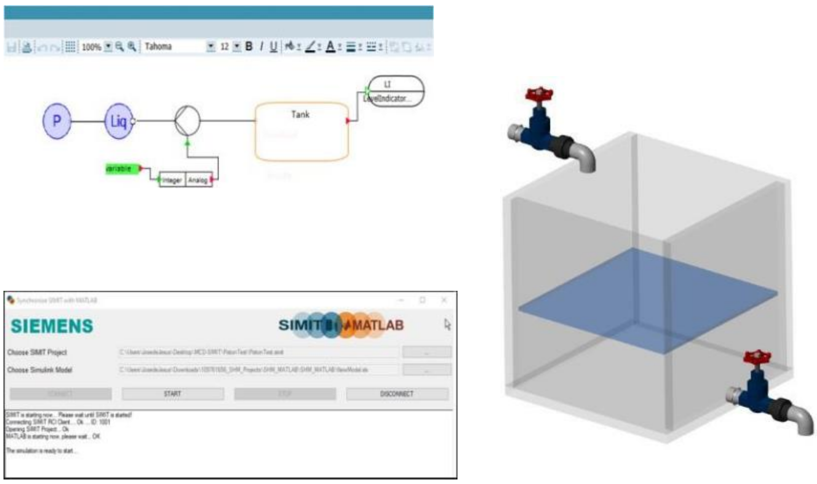


Figure 4. A Siemens SIMIT simulation (left) of a water level control system running within Matlab Simscape (right) developed for a process control course.

Case 3: Virtual Commissioning (VC)

Refers to a connection between the DT and an external control system, often used to debug programs. The information is exchanged using established communication protocols (Guerrero et al., 2014). For instance, an Arduino board can interact with Matlab in order to obtain a reaction from the DT mentioned in Case 2.

Figure 5. Representation of an Arduino card used to control the behavior of a system modelled in Matlab using a transfer function.

Case 4: Cyber-Physical Systems (CPS)

Consists in the connection of a DT with a physical system. Physical elements can trigger changes in the digital environment and vice-versa (Villagomez et al., 2019). Cyber-physical systems allow students to verify that the behavior of the digital twin is similar to that of a real product or process and understand what may cause variations between them.

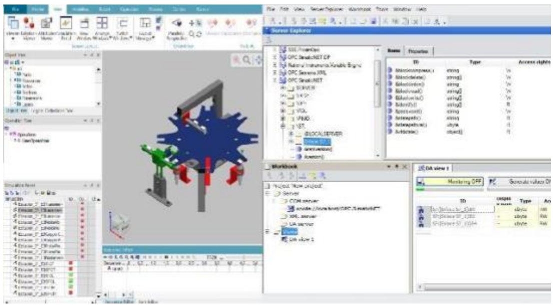


Figure 6. Monitoring of the interaction between a physical system, including sensors and actuators and its DT using specified communication protocols.

These cases were implemented across twelve courses which had a change of objectives and general strategies to fit with the implemented online synchronous and asynchronous model. In the former, students and lecturers interact online, while in the latter, lecturers assign activities for students to develop at their own pace which are reviewed periodically.

Before presenting how the aforementioned Industry 4.0 competencies were incorporated into the online laboratory courses, the traditional on-site approach, together with the course objective, and an overview of the activities performed are described. The courses have been grouped according to the main topic to allow for a simplified presentation. It is important to note that some are mainly theoretical, whereas others are laboratory-oriented. However, since the theoretical courses mentioned traditionally included a considerable amount of hands-on and simulations activities, they were adapted using the current pedagogical method and are therefore included in this work.

Courses on Process Automation and Control

Depending on the level of understanding required for their engineering degree, students learn about the analysis, design, implementation and evaluation of automatic control systems and logical controllers of batch-type, continuous and discrete processes. Traditional PBL based activities, with situations related to the regulation of physical variables (temperature, pressure, flow, etc.) in industrial systems, carried out on-site included:

- Interpretation of piping and instrumentation diagrams (P&ID), to define a problem in which students need to identify automation and control variables in industrial processes.
- Modeling and characterization with first and second order systems, or nonlinear electromechanical dynamical systems.
- Implementation of combinational and sequential logic processes using electro-pneumatics as well as Programmable Logic Controllers (PLC’s), microcontrollers and related technologies.
- Implementation of an automatic system considering security elements such as emergency stops and alarms.
- Tuning of continuous and discrete PID controllers via pole placement, root locus, and frequency analysis design, as well as the implementation of non-conventional control algorithms using artificial neural networks and fuzzy logic.

Courses on Mechatronic Product Design

Oriented towards allowing students to understand and apply various design methodologies (i.e. Stage-Gate, Integrated Product Development, Design Thinking, Lean Startup, Agile, V-Model) to develop a mechatronic prototype (Esqueda et al., 2019) while considering manufacturing constraints, technologies, and tools, as well as an analysis which ensures the viability of the business and desirability of the market. These courses are presented as POL since the student is guided through activities that iterate their design throughout the semester, having as outcomes, a finished prototype and business plan related to the idea proposed, that involves the:

- Evaluation of the feasibility of a product considering Design for Manufacturing and Assembly, Failure Mode & Effects Analysis, anthropometric analysis, etc.
- Production of a prototype solving a specific market need, iterated by means of primary and secondary market research, Quality Function Deployment, A/B Testing, among other tools.
- Presentation about the viability of both, the product, and the business to external multidisciplinary industrial reviewers and internal faculty.

Courses on Industrial Automation and Networks

Students learn to design, deploy, evaluate, and optimize production processes by applying Process and Product Lifecycle Management (PLM) solutions, together with operational technologies such as PLC's, industrial networks, and human-machine interfaces. An RBL approach is used by students to justify the development of activities based on multiple sources of information, such as articles published in journals and conferences with high impact factor. On the other hand, a PBL approach is used to carry out activities like:

- Modelling and simulation of production systems.
- Connecting production models to PLC's and industrial automation devices.
- Improving existing industrial operations using PLM solutions and Operation Technologies.

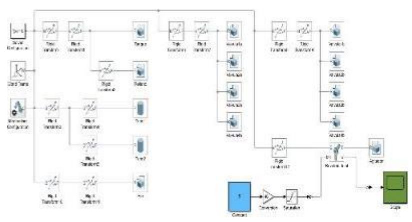
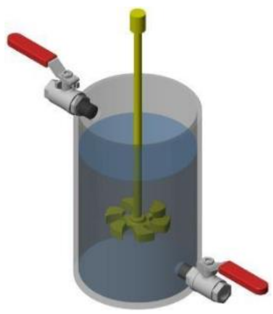
Courses on Mechanical Analysis of Solid/Fluid Systems

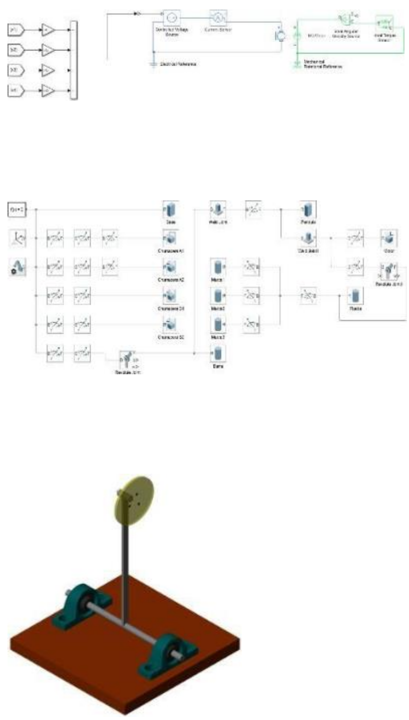
Students learn to study solid or fluid systems, analyzing their behaviors and reactions to changes of the surrounding environment. An RBL approach is employed, allowing students to use experimental and simulation tools to generate and test their own hypotheses about the topics covered. Activities involved consist in the:

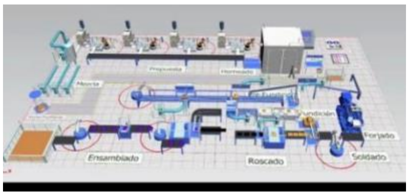
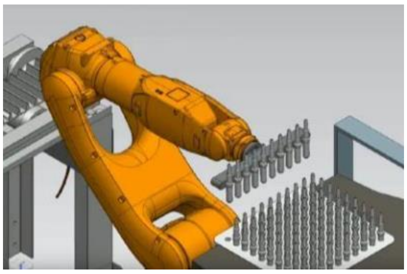
- Design and construction of a test-rig to measure the deformation of beams subject to varying loads, followed by a comparison of the theoretical and experimental results. Slight guidance is given in the use of specialized equipment, while students are encouraged to formulate and test their own research questions.
- Simulations of fluid-related systems to predict the behavior when subject to changing forces and geometries on a system of their own choosing. Optimizations and improvements for the systems are proposed according to the results obtained.
- Written reports are required to present the results of their studies using scientific writing and adequate formats according to the discipline.

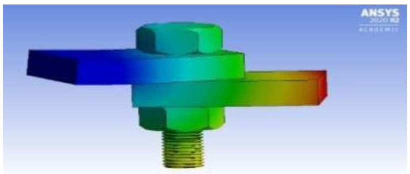
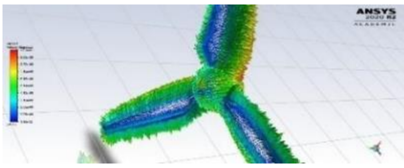
To complement the above traditional learning techniques, Industry 4.0 concepts were incorporated to develop related competencies by using and creating virtual environments and products to motivate learning in students. Thus, some study cases that show the implementation of this pedagogical approach are shown in the following table. The stage of the DTD shown in Figure 1 associated with each of the competencies is shown by the colored bullet, where more than one can be involved in a given course.

Table 1. Courses impacted by the implementation of the pedagogical model, competencies developed and examples of work carried out by the students. The color of the bullet corresponds to the stage of deployment used according to Figure 1.

Course names and benefited majors	Industry 4.0 competencies currently developed	Target Industry 4.0 competencies	Examples of successful implementations
Process Automation (theoretical course) Process Automation Laboratory Logical Automation Laboratory Majors: Chemical engineering Biotechnology engineering Mechatronics Engineering	Development of DT's to understand P&ID diagrams and the physical devices involved. Construction of DT's to validate the parametrization of first and second order dynamic systems.	Implementation of PLC control algorithms for the VC of chemical processes.	  DT of a continuously stirred tank reactor. Programming (top), behavioral simulation (bottom).

Course names and benefited majors	Industry 4.0 competencies currently developed	Target Industry 4.0 competencies	Examples of successful implementations
Modern Control Engineering (theoretical course) Control Engineering Laboratory Integral Automatic Control Laboratory Majors: Mechatronics engineering. Mechanical engineering. Digital systems and robotics engineering.	Development of DT's to validate the mathematical model of dynamical systems. Implementation of control algorithms for the VC of electromechanical systems. Development of DT's to test closed-loop control response of nonlinear unstable dynamical systems. Use of digital twins to implement automation techniques and validate the behavior of electro-pneumatic processes.	Build dynamic electromechanical systems and virtualize them to create CPS's. The performance of control schemes is evaluated using the generated data. Digitalization of automation and control processes to perform VC with PLC technologies.	 Balance control of an inertia wheel pendulum. DT programming (top), control program (center), 3D simulation (bottom).

Course names and benefited majors	Industry 4.0 competencies currently developed	Target Industry 4.0 competencies	Examples of successful implementations
Mechatronics Design (theoretical course) Mechatronics Laboratory Majors: Mechatronics engineering. Mechanical engineering.	Development of a DT for the prototype of the mechatronic product. Use of augmented reality to present the DT and obtain feedback from the target market. Virtual pitch with faculty staff and external guests from the industry using a DT.	Validation of the behavior of the DT to emulate the physical system, and exchange signals mutually.	 Use of AR to showcase the DT of the product.
Industrial Networks (theoretical course) Industrial Networks Laboratory Advanced Industrial Automation Majors: Mechatronics engineering. Digital systems and robotics engineering.	Development of an industrial production system's DT using Siemens Tecnomatix PLM solutions. Deployment of VC using Siemens PLC's. Deployment of a cyber- physical production system using PLM solutions, PLCs, and physical sensors and actuators.	Use of industrial Big Data and data-driven models and simulations to optimize processes.	  Model and simulation of a spark plug production system (top) and a simulation of pick and place operation connected to a Siemens PLC S7-1516

Course names and benefited majors	Industry 4.0 competencies currently developed	Target Industry 4.0 competencies	Examples of successful implementations
Materials Engineering Fluid Mechanics Majors: Mechatronics engineering. Mechanical engineering. Automotive design engineering	Development of DT to allow for system optimization. Validation of DT subject to varying conditions using experimental values.	Development of a CPS which mirrors the conditions of a physical system within a simulation environment to predict future behavior.	  Simulation of stresses generated on a simple nut-bolt assembly (top) and wind-turbine in the presence of uniform flow (bottom).

According to the above, apart from the engineering knowledge and skills that students acquire from traditional learning techniques, this pedagogical approach complements the educational models in the sense that it encourages the development competencies related to Industry 4.0 as shown in Table 1. However, the use and development of virtual environments and products, to motivate and improve the learning process in students, does not necessarily mean that they consider this beneficial for their professional development. Therefore, the following section aims to measure the students' self-efficacy perceived around the acquisition of knowledge through the development of these Industry 4.0 competencies.

Research Methodology and Key Results

As mentioned, there is a gap in the literature related to the sense of self-efficacy in online laboratories which implement Industry 4.0 concepts. Early research has shown that students have difficulty maintaining focus over long periods of time (Brunce et al., 2010), with even bigger challenges in the current context that might compromise the quality of the learning experience (Husseln et al., 2020). While most publications focus on evaluating the efficiency of the courses, little has been published regarding the sense of fulfillment of students enrolled in these courses.

At Tecnologico de Monterrey, students have increasingly expressed the relevance and importance that having a hands-on approach in the engineering laboratories has for them through focus groups, interviews and surveys. Since it is the belief of the authors that the voice of the student can work as a catalyst for innovation in Education, the authors decided to look into their sense of self-efficacy as an indicator of self-fulfillment in their learning. In particular when they cannot physically interact with the tools and equipment of the laboratories.

It is important to note that this same context is boosting the use of Industry 4.0 as a tool to improve efficiency and collaborative work in companies all around the world (Grodotzki, Ortelt, and Tekkaya, 2018). As new jobs require a deeper understanding of the use and development of such technologies, engineering education must also evolve to prepare the future workers for those positions. The research questions thus aim to validate this need for additional skills and at the same time increase the level of satisfaction of the students.

Moreover, education in this particular context involves a new set of variables which affect its correct development, which may lead to a different experience for every student. For example, their own adaptability, computing power, internet speed connection, and remote availability of laboratories and software were seen as the top factors that could generate significant differences in the students' experiences. Students' self-efficacy, as presented in the research framework by Lee & Mendlinger (2011), would then be measured by contrasting their sense of perceived usefulness (i.e. Online teamwork was more effective than meeting in person), perceived ease of use (i.e. Digital classes can perfectly replace traditional lectures), and perceived efficacy (i.e. The virtual practical approach enhanced my skills considerably) with affirmations related to the Industry 4.0 competencies approach (Adaptability: "I adapted quickly to online learning"; Personal Computer: "My computer allowed me to work just fine"; Online/Remote Facilities and Activities: "Specialized software and remote laboratories gave me confidence to interact with real systems").

Likert-scale questionnaires have shown to be very useful to measure self-efficacy as long as they are designed properly (Nemoto & Beglar, 2014), and were therefore used to collect data from students via a Google Forms online survey carried out in Spanish.

As described in Table 1, different courses were adapted to one of the cases previously presented and final projects were evaluated in order to verify the students' learnings of the semester. As previously indicated, one of the goals was to validate if this pedagogical method, based on Industry 4.0, would be of their satisfaction.

Undergraduate students who were enrolled in the aforementioned courses during the February-June 2020 and August-December 2020 semesters were invited to answer an exit survey that measured the impact of the work developed during those terms. The survey included 6 questions that were aimed at identifying the usefulness of the pedagogic method, their perceived self-efficacy (Lee & Mendlinger, 2011), and the context of use of the digital tools presented through a 5-point Likert scale. A total of 300 responses were collected. The most important characteristics of our sample of students are given in Table 2.

Table 2. Student sample characteristics considering their gender, age and field of study.

Gender	74% Male 25% Female 1% Prefer not to say
Age	5% 18-20 73% 21-23 19% 24-25 3% Over 25
Major	55% Mechatronic Engineering 17% Chemical Engineering 5% Mechanical Engineering 2% Automotive Engineering 12% Robotics Engineering 9% Biotechnology Engineering

The results associated with the students' perception of self-efficacy that were part of this test study are seen in Figure 7, where this heatmap was built up by contrasting questions related to the resources available to the students and their sense of self-efficiency within the courses. The number of students that selected the same response on the Likert Scale in both questions were counted and following this approach of grouping the results and analyzing them, some observations are presented:

- The majority of students felt they had adapted quickly to online learning, and most also reported that their computer is good enough to work in the online classes. This last point was a major factor since many of the activities done in the courses involved can be computationally demanding, and the success and ease of implementation strongly depends on the equipment used.
- In general terms, there seems to be a dislike towards online classes. However, this data was built based on the responses from two semesters and it is noted that this discouragement emerged mainly in the second semester studied, possibly due to students being jaded by the lockdown.
- While most of the students agree that the virtual approach was useful to them, it is also clear that whenever remote laboratories and specialized software were used in the courses, the overall acceptance of the online approach improves.

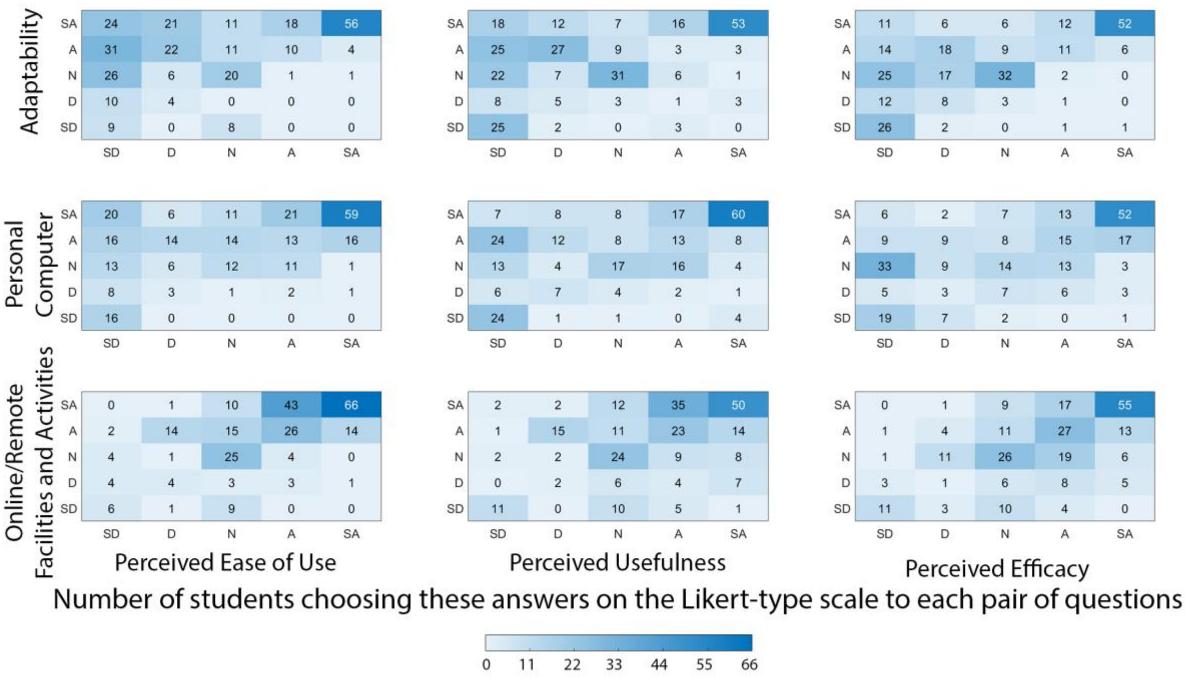


Figure 7. Correlation of questions linking the students' resources (adaptability, personal computer, online/remote facilities and activities) with their sense of self-efficacy in categories (perceived ease of use, perceived usefulness, perceived efficacy). Possible answers were "Strongly Disagree" (SD), "Disagree" (D), "Neutral" (N), "Agree" (A), and "Strongly Agree" (SA). The colors indicate how many students considered each pair of questions at the value indicated in the row (digital tools questions) and column (self-efficacy questions). The color scale reflects the registered number of responses, per pair of questions.

The data also shows distinct patterns which can be associated with the four sources of efficacy beliefs. For example, the possibility of using specialized equipment remotely and having an adequate computer will directly impact the perception of the students' success or failure in a given course. Since these factors may impede the correct implementation of an activity and the mastery experiences will be hindered. Furthermore, the varying levels of online teamwork developed and use of tools which allow interaction affect the vicarious experiences, since there may be little or no observation of other students, and therefore, the perception of the benefits of remote learning may not reflect the actual impact.

Discussion And Concluding Remarks

The COVID-19 outbreak and resultant lockdown have been the main drivers of digitization over the past year. Changes in the classroom have caused students to gain knowledge through the use of models, simulations, and telecommunications tools, where the latter are commonly used in modern industry since the beginning of the Fourth Industrial Revolution.

Online learning has many advantages over traditional classes. However, continuous improvement is required in its pedagogic strategy so that students can have a satisfying experience, particularly when they are unable to validate their skills in a physical environment such as in a laboratory. Lecturers therefore must focus on creating realistic virtual environments and rely on various forms of online or remote laboratories to ensure that students graduate from universities with the required skills and confidence to enter the world of work.

Due to the ever-changing demands and needs of the working world in terms of the skills, competencies, and knowledge required, the participation of industry specialists in the learning process is of the utmost importance. The industry now requires students who can adapt to radical changes, foster the digital transformation of organizations, and accept diverse points of view. "Incorporating key concepts from Industry 4.0 and the development of relevant competencies favors the exchange of ideas within companies, as well as collaboration with industrial environments in the coming years'' -Rebeca Gonzalez (ZF - Talent Acquisition Specialist in the Global Recruitment Center).

Over the course of two semesters, and after the onset of lockdowns in Mexico, lecturers at Tecnologico de Monterrey adjusted their courses to be delivered in an online format using telecommunication tools. At the same time, concepts and ideas related to Industry 4.0 were implemented to teach students through a novel pedagogical approach that allows them to develop skills, competencies, and knowledge which is required in this emerging industrial environment.

The implementation of this approach led to the identification of various factors which affect the development of the students' self-efficacy, as well as an evaluation of the impact that the use of technology and other tools have on the learning process. From the surveys, a rather positive outlook from the students' perception towards the proposed approach was noticed. As a matter of fact, from the first to the second semester of this study, answers shifted towards something more positive when involved in activities of this Industry 4.0 based model. However, we also believe that part of this was related to the professors also feeling more confident since the first semester they were forced to modify their teaching methods within the classroom and adapt them into an online learning system in a very short amount of time. The influence of the professor's self-efficacy assessment can also be a potential direction of future studies.

As stated in the introduction, this work was focused on two aspects of the students' self-efficacy: physiological reactions due to the COVID-19 pandemic and mastery experiences about Industry 4.0 activities. Therefore, three indicators were measured as an attempt to answer the posed research questions: the students' perceived usefulness, the students' perceived ease of use of the tools, and the students' perceived efficacy. However, this study can be complemented by considering the two additional aspects of the self-efficacy theory: social persuasion and vicarious experiences.

Social persuasion can play a significant role in the students' self-efficacy in the sense that seeing the importance that engineering professionals give to Industry 4.0 could serve as motivation for the students. However, it can also bias the opinion of a student if someone openly shares a different point of view. While some professors at the University continuously asked students about their sense of satisfaction with online learning, we do believe that an exit survey allowed us to reduce bias originated by social persuasion. On the other hand, vicarious experiences could be added to the analysis if, for example, new students observe the successful results that current students have in Industry 4.0 related projects or tasks.

The authors will continue to adapt their courses with the aim of strengthening the development of such competencies related to Industry 4.0 and thus, give the students an advantage over graduates from other institutions. The use of industrial digitalization, together with visualization tools, will remain an essential part of this new strategy and in coming studies, more of the key concepts related to Industry 4.0 will be brought over to the educational approach. Additionally, it was also noted that an adaptation of the methods used to evaluate hard and soft skills is required alongside the modifications which have already been implemented.

Further evaluations will be done to measure the students' digital literacy, industrial partners' perception of the development of the Industry 4.0 competences, as well as a continued analysis of students' self-efficacy perception.

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The Impact Plan: anticipating the impact of university students' final projects

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Abstract

University students often struggle with choosing a topic for their final projects due to the lack of a supporting and defining framework for said selection. Should the student be oriented toward reflecting on how each of the possible topics to choose from can become an impactful project in the short, mid and long run, maybe that selection becomes a less anxious moment and the engagement with the project activities more relevant and meaningful to the student, being particularly pertinent when students can anticipate different levels of impact that range from their own life to a wider community.

In this paper a visual tool is proposed, aiming at simplifying the moment of choosing a project by matching its anticipated impact with the users' motivations, capacities, ambitions, and perceptions of value. A prototype was designed and tested with a group of students enrolled at a creative postgraduate course, in a professionalisation-led module, under the UK's first 2020 lockdown restrictions. The tool proved helpful in supporting the students' decision making when having to select a topic to be developed in the context of a communication design project, and to which they were able to align their personal interests, their career ambitions, and the way they perceived themselves as contributing to a better world. Since this is a cyclical experience, both during a design learning environment, but also in design practice, the Impact Plan, which was conceived with design students in mind, configures as fully replicable in other academic (and professional) contexts too.

Keywords

Design Thinking, Impact Assessment, Purpose, Project Selection, Speculation, Post-pandemic.

Introduction

Whilst academic achievement is still understood as a significant metric for employability, students increasingly see the need to add value to such achievements, to gain an advantage in the job market (Berger & Wild, 2017). At a time when they face the threats brought by the predicted high levels of automation, and now the impact of the COVID-19, those graduating amid the pandemic face the enduring and still unknown implications of this enormous split the world is experiencing – and that will shape their understanding of society as a functional system. In normal circumstances, there is always a great deal of uncertainty when entering the workforce after graduation; for those graduating soon or in the next couple of years, that uncertainty goes beyond the short-term issue of finding their first job, because nobody knows what the (job) market will look like post-pandemic. It is, maybe, the right moment to reassess priorities and the perceived notion of value.

This research intended outcome is an impact-led tool to connect students' reflective practice with their pre-professional identity, aiming at anticipating (and speculating on) the short, medium, and long-term outcomes their projects will have in their lives and the lives of others. It aims at providing students in final years of both undergraduate and postgraduate studies with a design thinking structure for reflecting, planning, and prioritising their experiences for heightened employability, guiding them through the essential contexts in which their final projects can trigger or build on some impact.

The world needs design (thinking) more than ever

According to Watts (2006), paying more attention to students' employability responds to their principal motivations for enrolling on Higher Education (HE) courses. The latter are described by Smith (2016) and Leman (2018) as leading individuals to enhancing achievements at work, progressing in the current career path, gaining access to better employment, and developing talent and creativity. These motivations are, supposedly, instructed by a pre-professional identity which entails a self-understanding of the skills, qualities, culture, and ideology of a student's intended job (Jackson, 2016).

Personal Development Planning (PDP) is defined as "a structured and supported process undertaken by a learner to reflect upon their own learning, performance and/or achievement and to plan for their personal, educational and career development" (QAA, 2009 p.2), emphasising the student's agency and ownership. Constructivist theories of reflexive identity formation defend that reflexivity is deeply associated with a constant need for reinventing the self (Giddens, 1991; Beck, 1992). And although PDP can be approached within a learning frame, the latter theories have been having an increased influence in the field of career development by "encouraging people to identify constructs and themes within their career narratives and to use these as a basis for future action" (Ward & Watts, 2009, p. 9). It should be noted that reflexivity differs from reflection: according to Rennie (1992), reflection involves self-awareness, while reflexivity involves reflection plus agency within such self-awareness. Thus, as suggested by Savickas (2016, p. 84), "reflexivity fosters a self-awareness that flows into intention", being powered by motivation.

According to Kieslinger et al. (2009), motivation is one of the key factors for successful adult involvement in learning and knowledge sharing activities. Duckworth, Peterson, Matthews and Kelly (2007) performed a study on grit, which is defined as perseverance and passion for long-term goals, suggesting that the achievement of complex objectives associated with intricate problems entails not only talent, but also its application over time and in a sustained and focused manner. Solution-oriented behaviours are extensively explored in the context of Design Thinking (DT) and, lately, by the educational community in general. Being DT a human-centred process, it delves into the development of active listening, agile thinking, and forecasting, in a continuous fail-and-learn-fast style (Curedale, 2013). The opportunity to address and solve complex dilemmas that arise in real-life problems helps students develop contextual knowledge and content, as well as reasoning, communication, and self-assessment skills. Thus, such a practical approach sustains the students' levels of interest and motivation because they easily understand the transferability of these skills into real situations they may encounter in their future. It should also prepare them for pivoting, iterating, adopting improvisational approaches, and thinking in a "How Might We" kind of way. How-Might-We (HMW) statements work as prompts heavily relying on abductive logic (Dunne & Martin, 2006; Dorst, 2011). According to Gottlieb et al. (2017):

> *The "how" assumes that there is a solution. "Might" assures it is acceptable whether an idea works or not. "We" emphasizes collaboration. The prompt works as a source of inspiration for idea generation that broadens perspectives, discovers connections, and generates unexpected ideas (p. 23).*

LaRossa (2020) tells us how Milton Glaser used to ask his design students to write a detailed place description of their perfect day at work five years in the future. The author also explains that "imagining the future in detail is about designing a destination – a vision to hold on to when things aren't going as planned. This same mentality helped me stay focused on my career goals".

A tool that provides students with guidance towards self-awareness and the subsequent construction of career intentions may well be a way to help them build their agency and authority in finding meaningful solutions for real-world problems (even if future ones) of their concern. When Design is a field inherently interdisciplinary, often focused on anticipating a future that does not yet exist and on solving complex problems for multiple stakeholders (Tharp & Tharp, 2018), such a tool would set the ground for speculation of impact. Students need the experiential and reflexivity-led tools that allow them to develop and prepare as humanity-centred individuals, looking into the broader landscape with a sustainability lens and transformational attitude, developing greater awareness concerning the contexts we live in and, from there, adjust their career ambitions and find their place in a vertiginously changing world.

Although several visual tools (e.g. customer journey maps, question ladder, business model canvas, personas, etc.) have been created and developed in the last few years to support innovation and design thinking (Lundmark, Nickerson & Derrick, 2017), none have been identified in establishing the link between reflexivity and speculation at the different stages of possible impact. Currently, many students increasingly question their career prospects and, more than ever, both academia and industry are being asked for clear contributions to the wicked problems that society faces. It seems relevant to systematically enhance the notion of impact, guiding students through the selection of projects (namely when they need to choose one from a pool of many, either proposed by teachers or self-negotiated) that best align to both their existing and desired skillset, and their ambition towards making an impactful addition to the world.

Hence, the question guiding this project is: How can students anticipate the impact of their projects?

The Method and empirical process

This project is qualitative in nature and uses hermeneutics of action as the supporting framework for interpretation (Giddens, 1993). It is part of an ongoing larger research that follows a constructivist grounded theory approach (Strauss & Corbin, 1994).

Benchmark of existing tools

According to Gilje (2020), central to hermeneutics of action is that what actors do must be contextualised in order to understand the intention behind the action (in this case, the most well-known and conscious action has to do with completing a university degree). Hence, the research started with a benchmarking exercise on existing employability-led tools and canvas-based activities to support design and innovation, decision-making, speculation, and impact-centred thinking. A total of 312 canvases, boards, diagrams and other generative activities were collected from seven different sources and retrieved from either agencies/practitioners' online resources (official websites, blogs, wikis), monographies and scientifically developed resources. The analysis developed from a collection of 35 tools selected based on the presence of elements that would frame their use under design and innovation, decision-making, speculation and impact-centred thinking. A framework of analysis was purposefully created to guide the scrutiny of the selected generative tools (Lelis, 2021).

Defining principles and value moments

Abductive reasoning would have to be the thinking mode orienting the use of the desired tool. Dorst (2011) explains abduction as a process of reasoning that can be broken down into two forms, being one of them the case in which both the HOW and the WHAT attached to a problem are unknown: only the value/purpose, represented by the outcomes and the impact that one wants to achieve is clear. Hence, two design principles were considered to answer the research question:

- Principle 1 – To the student, the Value (WHY) is the best-known variable. Hence, it needs to be represented to the best extent to, subsequently, inform both the HOW and the WHAT (Figure 1).

Figure 1. Representation of Principle 1.

- Principle 2 – The Value describes the purpose (the intended impact), informs the rationale for taking up the project/activity, and must be at the centre of the student's speculative process (Figure 2).

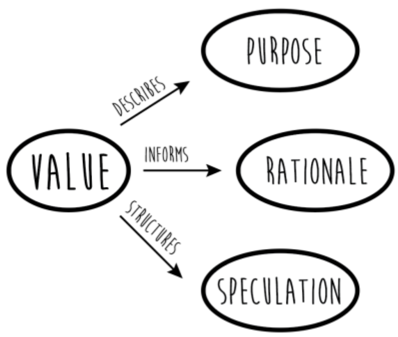

Figure 2. Representation of Principle 2.

Value has been divided into three moments: 1) Self & instant reward, 2) Independence outcome, and 3) Humanity-centred impact. These are linked to different sorts of outcomes throughout time (short, medium and long-term), informed by both the most common values to human nature (Schwartz, 2006), the requirements of societal and professional functioning (Persson et al., 2001) and the theory of human motivation (Maslow, 1943):

- *Self- and instant reward.* This value moment focuses on immediate rewards (short-term outcomes) inherent in the experience of performing certain activities or engaging with a specific project. According to Persson et al. (2001), enjoyment is an essential characteristic of this dimension and, in some cases, individuals can enter a state of flow (Csikszentmihalyi, 1990) when the activity provides an intense challenge while matching their skills. In this case, the student chooses certain aspects regarding the completion of a selected project because he or she enjoys them. The impact of engaging with the activity/project will be mainly on the Self as it would relate to the students' academic achievements, where belonging to a course and engaging with its domain of activity plays a vital role in the student's motivations. That corresponds to an impact stage categorised as Studies (Figure 3).

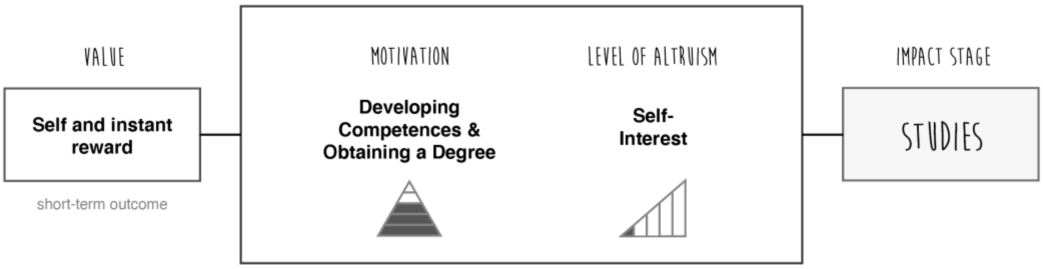

Figure 3. Value moment "Self and Instant Reward".

- *Independence outcome.* This value moment is about the student's career intentions. It is characterised by a medium-term looking ahead: the student is asked to anticipate the impact that the activity/project may have on improving or acquiring capacities/skills they will need to follow a specific career path. Such reflexive exercise will allow students to become aware of their future situation and needs, possibly nudging themselves towards understanding their interests, preferences, passions and, simultaneously, the issues they face and that they would like to solve. This level of impact would relate to the students' careers and professional ambitions and is driven by motivational grounds related to achieving esteem and expertise recognition, at a level of altruism where cooperating and responding to cooperation are deeply connected to "acting in a way readily grasped by others" (Zwick & Fletcher, 2011, p. 4). This moment corresponds to an impact stage classified as Career (Figure 4).

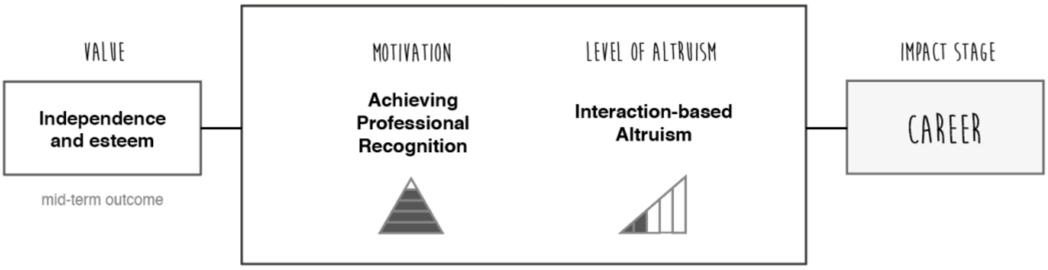

Figure 4. Value moment "Independence and Esteem".

Humanity-centred impact. This long-term outcome is grounded on Universalism values that contribute to positive social relations. It is driven by the others and by the planet, with sustainability at its core. The student will, this way, realise that his/her performance and engagement with the project will potentially lead to a concrete solution that is of value not just to them but also to a larger number of individuals, ranging from local communities or industry sectors to international causes. Hence, this would be inspired by higher-level altruistic motivations related to achieving a solution to a wider problem and possibly leading to a sense of fulfilment. Sustainability was broken down into its three dimensions as defined by the United Nations 2030 Agenda – Economic, Social and Environmental – used as the impact sub-stages defining the third value moment (Figure 5).

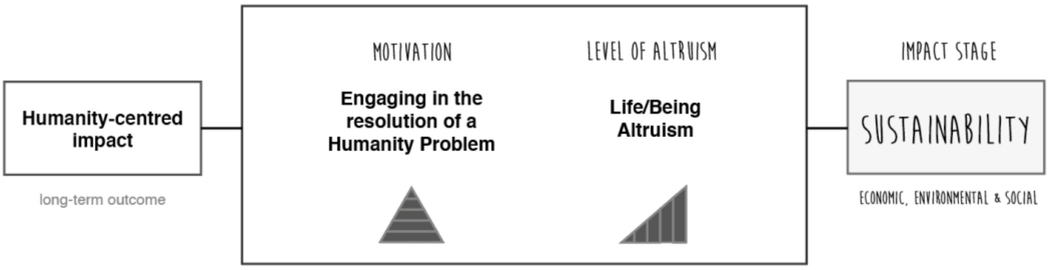

Figure 5. Value moment "Humanity-Centred Impact".

The development of the Impact Plan prototype

The previous stages led to prototyping a tool that would help answer the research question. The Impact Plan was designed as:

1 a printable Canvas for students to map their notions of Value (Figure 6), which is accompanied by:
2 a deck of Outcome Cards (Figure 7) grouped into the five categories identified under the three Impact Stages – Studies and Career, both with two areas of impact (Development and Wellbeing) for the anticipation of "Impact on Me", and Sustainability's three dimensions: Economic, Environmental and Social, for the foretelling of "Impact on Humanity" (Table 1).

On one of its sides, the cards include several prompts for outcome speculation and rationale-led narratives to emerge. They allow students to assess the impact they anticipate for each project/activity under consideration, using a scale ranging from -2 (for negative impact) to +2 (for positive impact). On the other side of the card, the student can write down the result achieved by adding the scores of all prompts from that card. The canvas would be used to gather the relevant cards under each impact stage and to register the quantitative final scores that would be the sum of the results from the cards used to assess each topic or project under consideration. It would also allow students to note down the impact prompts they positively assessed in the cards to draw and visualise the possible interconnections between the three stages of impact.

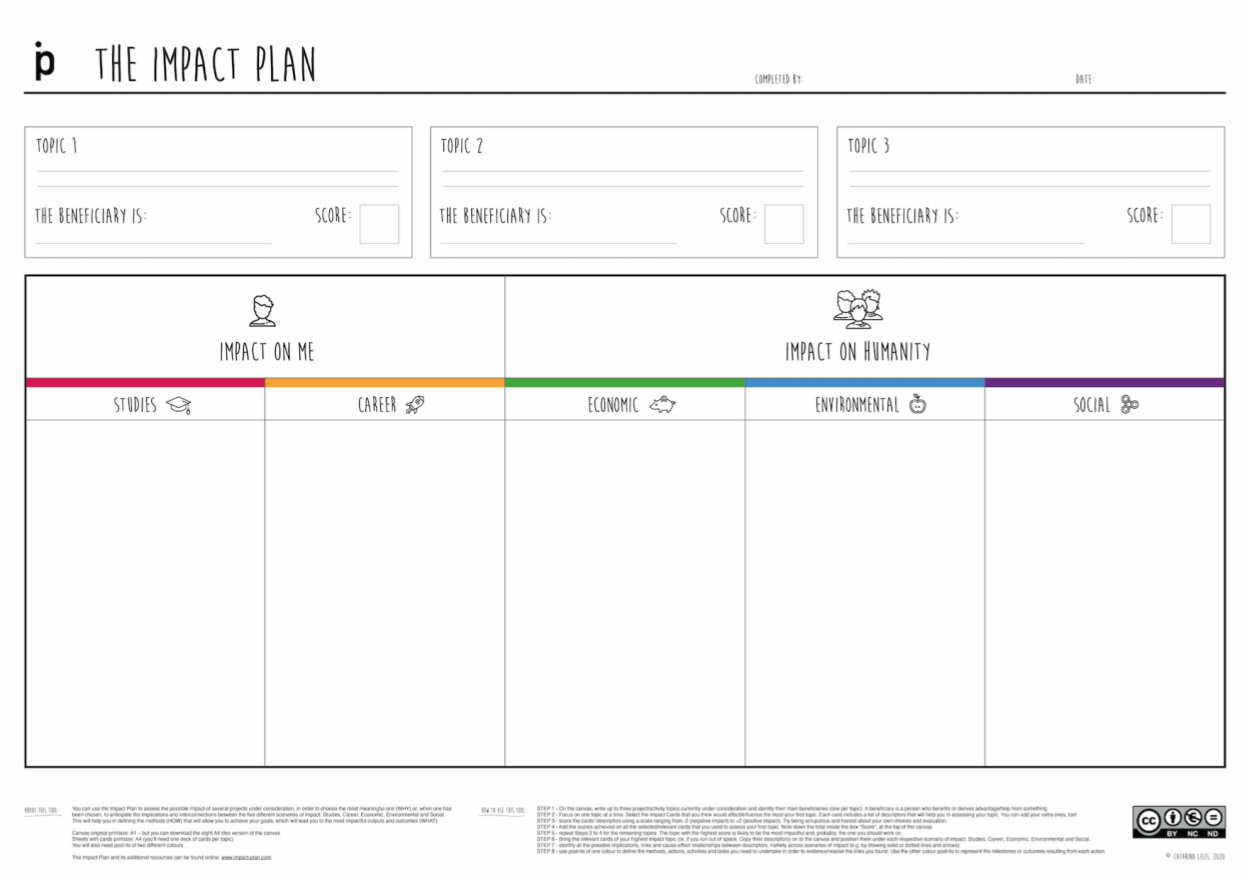

Figure 6. The Impact Plan canvas

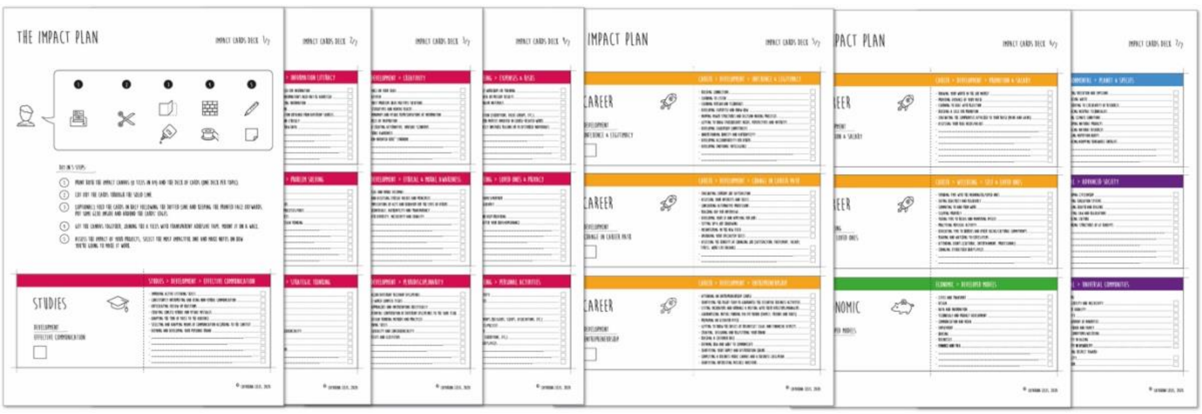

Figure 7. The deck of Outcome Cards

Table 1. The five Impact Stages used to categorise and organise the Outcome Cards

Impact on…	Impact Stage	Areas of Impact	Outcome Card
Me	Studies	Development	Effective Communication Information Literacy Problem Solving Strategic Thinking Creativity Ethical & Moral Awareness Pluridisciplinarity
		Wellbeing	Expenses & Risks Loved Ones & Privacy Personal Activities
	Career	Development	Influence & Legitimacy Change in Career Path Entrepreneurship Promotion & Salary
		Wellbeing	Self & Loved Ones
Humanity	Sustainability: Economic		Developed Models
	Sustainability: Environmental		Planet & Species
	Sustainability: Social		Advanced Society
			Universal Communities

There is no specific order on how the canvas and cards ought to be used. Ultimately, these are meant to be scoring devices to, firstly, back up the student in choosing the most impactful and personally relevant project/activity. For that, he/she will have to engage in an informal speculative exercise about future scenarios in which: 1) users would be involved given the particularities of each project, 2) projects would have implications on their lives and, 3) ultimately, in the lives of many other.

Implementing and testing the Impact Plan

The tool was implemented in the context of a Design-informed and professionalisation-led module, in an Advertising and Branding master's course from a London-based university, when all assessment strategies had to be revisited due to the first lockdown in the UK, and when all activities moved on to online/remote contexts. For that, the module leader prepared an activity brief entitled "Rethink:Remake the World", guided by an inspirational motto (Extraordinary Times require Extraordinary People with Extraordinary Ideas) and a question-based agenda:

- What are the new institutions needed to recalibrate the world?

- What new economics are required for an equitable society?
- What new products or services are needed?

Students were invited to form teams considering the lockdown constraints. Their fictitious client would be the “New World Order” – representing any possible entity with the power and interest to engage with the resolution of their selected problems. Students would have to deliver a communications product and strategy to the client after assessing the impact of different topics of their preference, using for that the Impact Plan. The latter stage is the one under analysis in this paper, after a set of informal interviews with eight students (out of 25), three mentors and the module leader.

Findings

The 25 students distributed themselves in seven “teams” (three students decided they would proceed individually) which were asked to identify three complex topics that would deserve rethought and remaking. Because of the first COVID-19 lockdown in the UK and moving all teaching to remote activity, half of the students returned to their home countries, to places as apart as Portugal and Japan. That meant the canvas would not be printed out as an A1 to be used in the classroom – as it had been designed for – but would have to be made available fully digital. The researcher created a PDF containing a tiled version (the whole canvas split into eight A4 sheets), designed the deck of cards with full instructions, and all materials were shared with the students via the university VLE.

Freestyle canvas

Some students managed to get the canvas printed and mounted on a wall at their homes (Figure 8, top left), making sure we could see these behind them on our videoconference meetings. Others, to whom printing the canvas would be either too onerous or a break of the lockdown rules in place, manually copied it onto blank sheets of paper and recreated it the best they could, following its original structure and/or colour coding (Figure 8, bottom left). One group re-arranged the canvas, making it more "elastic", in the sense that the only structural boundaries were determined by the three topics under consideration, allowing the five different stages of impact to blend (Figure 8, right).

Impact on Me X Impact on Us

As they were working in teams but separated from their peers, the completion of the canvas went through an initial distance-based issue: while every student was supposed to complete the canvas with, at least, their individual Studies and Career impact scores, in the end, each team would have to have one single canvas that would represent their aggregated values and impact scores, from the perspective of a team, naturally composed by different individuals, with diverse skills, interests and career ambitions. Therefore, deciding on who, from within the team, would complete the team canvas was mentioned as one of the problems students had to face since it was perceived as a highly responsible task given the lack of physical proximity between peers.

Eventually, the anxiety caused by distance-based teamwork was overcome, as evidenced by the students’ feedback, received by email:

… I never thought this would actually work for team-based projects! I tell you, there was a moment in which I was like "oh-oh, this is gonna blow".

Each one of us made a different use of the canvas, and for a while we were sort of puzzled on how we would get the whole thing together since we were resorting to different representations and organising systems, but it really helped us to better understand the relevance of each topic, once we managed to identify the similarities in our results.

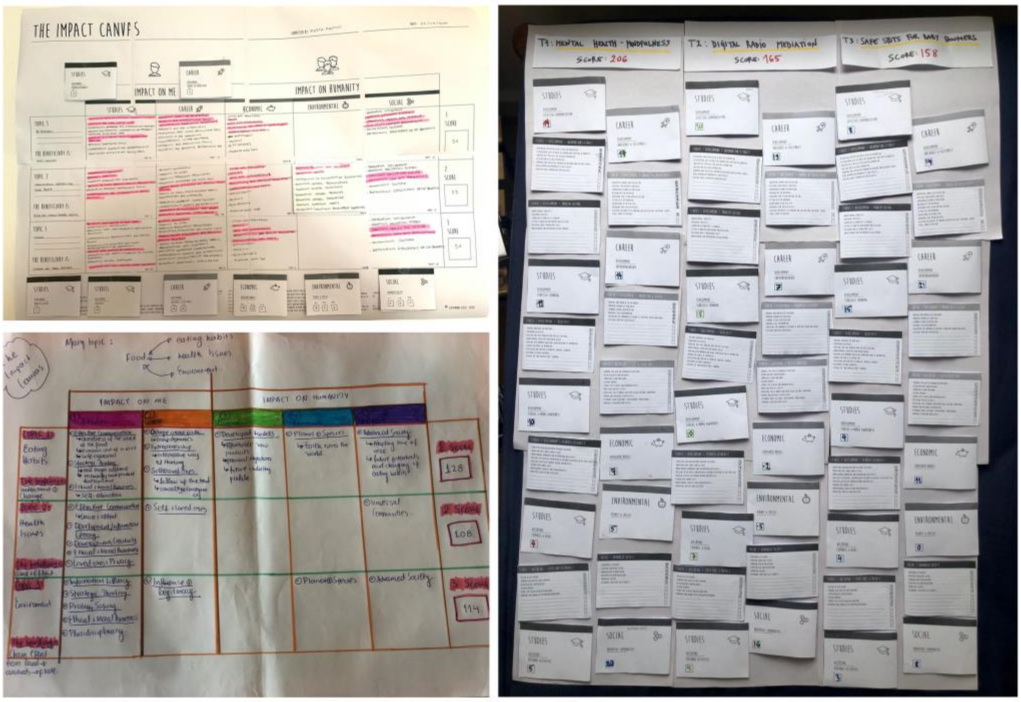

Figure 8. Examples of how the Impact Plan was used by the students.

Evaluating the selected topics

As anticipated, given the context, the topics were mostly COVID-19 and lockdown-related, or even, given the week in which the tool was applied, inspired by George Floyd's murder (Table 2). Ten alumni from previous editions of the same MA course were invited to act as mentors and to identify the teams they would possibly guide throughout the rest of the exercise. For that, each team had to pitch their three topics in a properly setup group videoconference call; since both students and mentors were distributed all over the world, it was agreed that ECT would be the friendliest time zone. These presentations allowed a very straightforward alignment between teams and mentors, as the latter could identify affinities between their own previously developed Master Projects (or current interests) and the presented topics.

Following this, each team used one deck of Outcome Cards per topic to score the possible impact their three potential projects might have (Table 2). Despite the details in the instructions that have been prepared to simplify the use of the canvas, again, the teams approached the scoring system in different ways: whilst some achieved very high impact scores (e.g. teams 1, 4 and 7), others managed to keep numbers consistently low (e.g. teams 2, 3, 5 and 6). That had to do with the fact that higher impact scores were retrieved by adding up all the partial scores from the assessed Outcome Cards, while the teams with lower impact scores calculated the average of scores obtained in the five impact stages (Studies, Career, Economic, Environmental and Social).

Table 2. The process of scoring impact of the Rethink:Remake topics per team

Team #	The teams' three original topics	Score	Selected topic
1	1. Safe Locations for Baby Boomers 2. Online Environmental Radio 3. Mental health and awareness	158 165 206	1. 2. 3. Mental health and awareness
2	1. VR for Music Festivals 2. COVID-19 communication for blind people 3. Cinema industry during the pandemic	28.5 20.0 12.4	1. 2. COVID-19 communication for blind people 3.
3	1. Balcony on a lift 2. Dating safe venue 3. Second skin masks	20.85 21.45 22.20	1. 2. 3. Second skin masks
4	1. Balancing the workplace 2. Making the most of time with the family 3. Eating habits and disorders	171 152 182	1. 2. 3. Eating habits and disorders
5	1. Greenhouse gas emissions 2. Air pollution levels 3. Nations' self-sufficiency	45 69 77	1. 2. Air pollution levels 3.
6	1. Domestic violence 2. Immigrants under lockdown 3. Safe dine-in environment	23 17 15	1. Domestic violence 2. 3.
7	1. Re-inventing Stadiums 2. Public transport hygiene 3. Police violence and authority	105 108 101	1. 2. Public transport hygiene 3.

Most of the teams selected their final Rethink:Remake topic based on its impact score (the highest from all three, see Table 2). The students mentioned that they found this had been a reassuring process since it confirmed their implicit inclinations:

> *We found the impact plan very helpful. It was interesting to see that the scores achieved by us as a team were fully aligned to our own personal gut feeling about the most impactful topics. I am 100% positive on the impact our project may actually have.*

> *I know now what other skills I need to develop; other than the ones I'm developing in the MA.*

Nonetheless, two teams (2 and 5) chose a topic that ranked second. When asked why, both teams referred to the influence of the discussion they had had with their mentors, at the time when they were about to choose their topic.

The role (and influence) of mentors

The mentors seem to have had a similar perception; one of them shared the following statement:

> *Helping the students through the phase of topic selection was quite straightforward. Our first meeting began with the mentees presenting their thought starters for each topic. (…) Together we had an in-depth discussion on the chosen topic which made it clear that they had gathered comparatively more data on it and were eager to learn more about it. I could tell they were genuinely more passionate about this topic and the impact score it got was very encouraging.*

In the context of their Master's course, both teams' mentors had worked in projects that were very much aligned to the topic these teams ranked second and eventually chose: in the case of team 2 – which selected topic 2 (COVID-19 communication for blind people) with 20 points as opposed to topic 1 with 28.5 – their mentor had designed a beverages packaging solution for the blind as part of her own Master's Project, and as for team 5 – which chose topic 2 (Air pollution levels) with 69 points as opposed to their topic 3 with 77 – during her studies, their mentor developed a keen interest towards biophilic design in interior environments as a way of compensating the exterior levels of air pollution.

Given the tool's open and constructivist "operative system", subversion, or rather, influence, can always happen – without it being seen as problematic. Students might come across many other influential factors that go beyond their mentors and which could make them choose a secondly or thirdly rated project. Besides this, since students are not obliged to use all the cards (e.g. not every project nor every individual leans toward entrepreneurial ventures, meaning the Entrepreneurship card can be considered useless and, therefore, discarded), the numerical scores will differ from project/topic to project/topic, potentially leading to unbalanced quantitative results. The obtained score is helpful, but it is not expected to, alone, lead to decision-making, namely when gut feelings and emotions can play such an important role (Damásio, 2006).

The lecturer and the supporting platform

Even though students were given about ten weeks to complete the Rethink:Remake project, from the moment they received both the brief and the Impact Plan resources, the module leader defined clear milestones and, by the end of the third week, all groups would have to have a mentor and one topic, selected from the three they would initially propose. The lecturer made available an online platform to gather the brief, the mentors' bios and profiles – mostly to ease the matching process – and, as the work progressed, the deck of slides of each team's proposals. In his opinion, the Impact Plan proved to be a very flexible tool, mostly relevant at the incubation stage of any project, where users benefit from engaging with non-prescriptive language or constraining structures, hence allowing them to put ideas together, resorting to whatever language they want:

> *When students are tasked to engage with big real problems and create, develop and execute innovative and disruptive solutions, as with our Rethink:Remake project, then the Impact plan was the decisive tool for understanding their solution's potency from personal, professional and ethical dimensions, enabling them to see the full extent of their idea's impact and application, without the use of an overly academic language but rather in a very conversational way. The results were astonishing.*

Discussion

This paper provides an overview of the potential of a visual canvas following an ontology grounded on reflexivity and speculation. The Impact Plan is suitable to be used as the very first board or tool, before any other visual canvases available and that have been designed to support the other stages of problem-solving and design-based activity. Completely aligned with the Future of Design Education (2020) initiative, which “focuses on design practice components that impact people, communities, and society” (2020, p. 3), this tool will orientate users towards identifying the WHY and picking up the most purposeful and meaningful (motivation-oriented and value-led) project or activity to deliver an impactful outcome, both on the Self and the Others. In fact, in The Double Diamond model proposed by the British Design Council (2021), the first diamond represents the quest toward “designing the right thing” and implicates an exploratory stage of research (Discover) seeking answers to WHY: Why is this a need? Why do people behave the way they do? Why is this relevant? but also, Why shall I/we explore this? Hence, the Impact Plan has been designed precisely with the topic selection moment in mind, to help users sharpen their perspective on the challenges they may face and to keep a more holistic view of how relevant and impactful their solutions may be as their projects evolve.

All teams were invited to ask the above questions, and the completion of the Outcome Cards allowed them to identify (at least partially) their answers, although two teams seem to have been equally influenced by their mentors’ answers – which may be a sign of the mentors’ propensity for a higher level of involvement in the project. The differences between the outcomes achieved by teams who selected the highest impact score and those who resorted to other decision-making variables will be interesting to analyse.

Moreover, the Impact Plan works not only as a selective device for users to choose from different available topics, but also as a triggering instrument for subsequent practice (such as definition, ideation, prototyping, testing and evaluation). From that perspective, it has not been fully tested (namely regarding assessing the actual impact of the outcomes the students achieved at the Rethink:Remake), but its current prototype seems to have helped confirm the basic premises.

Future Work

Despite its original orientation to individual decision-making, the Impact Plan seems to have worked rather well in aiding groups or teams in making informed decisions. This justifies an additional stream of research focusing on how the wisdom of crowds, quorums, confidence, and collective behaviour influence or are shaped by (shared or not) values and identities.

Given the physical distancing constraints imposed by the pandemic – and since the tool has proved to be useful for teams as well – the Impact Plan is now moving with its template into a fully online digital workspace for visual collaboration (Mural®). Here, users can, synchronously, complete their canvases together, regardless of their location, hence mitigating the printing-related limitations they may have to face. Moreover, a website has been created and published and both canvas and cards can be either downloaded or requested by email, respectively (www.impact-plan.com).

The following step will involve testing the tool in a non-academic industry context: the impact stage Studies can very smoothly adopt a different and more generic label such as Continuous Personal Development or even Learning, which would allow practitioners from any industry or sector to use the canvas. A testing protocol is currently being established with a country-level energy regulator which aims to further develop their design thinking toolkit.

At a later stage, to create a sound experience by which users can go beyond the purpose (WHY), further accessories need to be developed so they can move on onto the working principle (HOW) and both the ideation and development of possible outputs (WHAT), all three dimensions feeding each other and interwoven. That may lead to some kind of artificial intelligence-based resource that 1) real-time gauges and matches the users' inputs on the impact scoring interfaces (the canvas and the cards) and 2) virtually, allows the visualisation of anticipated impact scores on the fly, with a much clearer sense of the possible implications attached to a specific Outcome Card prompt being assessed or not.

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Inquiry-based learning approach for a systematically structured conceptual design process: Design project for disabled people

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Abstract

With the projects implemented in the 'Design for the Disabled' course in Gazi University 2019-2020 academic year, fourteen students are asked to develop solutions for the problems of disabled individuals, which is one of the real-world issues, while gaining professional knowledge such as critical thinking, idea generation and learning the conceptual design process. In addition, it is aimed to increase their learning motivation and interest in social design projects. It was learned that the students did not carry out a design project for disabled individuals in their previous projects. Throughout the semester, students developed their projects with a conceptual design matrix consisting of Data Collection, Primary Analysis, Secondary Analysis, Synthesis, Hypothesis, Preliminary Design and Final Design stages. Students were asked to present their projects at the Final Design stage. The course was conducted through online classes during the Covid-19 Pandemic for twelve weeks. Students are enabled to experience an interdisciplinary critical process. Thus, successful solutions and new models have been developed in projects in terms of product and space.

Keywords

Design for disabled, design education, fuzzy front-end design process, conceptual design process, design toolkit

Introduction

Industrial Design is a strategic problem-solving process (WDO, 2015). While the scale and the scope of the problem changes, the design process (DP) does not, its stages progress as repetitive and cumulative.

DP has descriptive steps and encourages an informed systematic decision-making approach by avoiding intuitive interaction (Leon and Laing, 2014). There are many different types of the DP, and they all contain analyses, synthesis, creation, and evaluation (Zimmerman et.al, 2011).

The early phase of the DP has more importance (Sanders, 2005) activities where problems and opportunities are defined (Cagan et al., 2002; Wormald, 2011; Sanders and Stappers, 2012). In the late design phase, ideas turn into prototypes and into products. Both phases require different content and format research (Sanders, 2005). Educators and researchers are looking for new methods to use in the early phase of the DP (Sanders, 2005). Much of the research conducted by designers and anthropologists since the early 1980s for the benefit of the product development industry has been related to the early design phase (Cagan et al., 2002; Wormald, 2011). The early phase of the DP is described as fuzzy front-end, as the DP and issues are ill-defined and not structured (Deschamps and Nayak 1995).

The activities in the early and late phases of the design are different. The late design requires the use of technical tools to solve well-defined problems in terms of form or structure. Conceptual design process, which is the early phase of design, is about developing new solutions and ideas. The conceptual process begins with questions and temporary design features and continues with synthesis. Good conceptual design (CD) stands for innovation, and it occurs when an innovative design consciously tries to create a design. In other words, it is the process of establishing relationships between sub-functions of design to achieve the design goal and objective through a chain of reasoning (Sturges et.al, 1993).

Correct data is needed to establish the relationships in problem-solving. Enhancing research in the early DP enables the creation of consistent cause-effect relationship between the design problem and its solutions, and increases the design quality (Payne, 2013). Archer (1965) states that in DP, creativity is the basic connection which is established in between the design idea and problem and indicates that when the solution emerges from data interaction, the design problem can no longer be ill-defined. In the 'Notes on the Synthesis of Form' by Architect Alexander, the author has adopted the idea that every decision made in the DP should be supported by data and design should be an independent process from the persons (Selau et.al,2020).

To generate design ideas, the data about the design problem area should be used (Kokotovich, 2007). The design problem should be structured before generating ideas (Mathias, 1995; Ho, 2001; Restrepo and Christiaans, 2003). Problem structuring refers to the process of reflecting the problem and its desired result (Simon, 1973).

After research and before the solution, insights that lead to design begin to emerge. It was concluded that the perceptual act underlying insight in design is more like 'bridging' the gap between the emerging problem and the solution rather than 'jumping' over a cliff (Cross, 1997; Akın, 1997). These insights can be generated by analysis and synthesis of research data, but unlike design research, this part of the DP is often ill-defined. Analysis and synthesis are underrepresented in academic and commercial literature and discussion. Although analysis and synthesis activities are extremely critical for design studies, the lack of definition means that it is difficult to teach and explain to students (Payne, 2013).

In the early stages when innovation and creativity come to the fore (Wormald, 2011), students discover the problem, try to understand it, collect data, try to make sense of the data and structure the problem (Kolko, 2010). It gains insight, establishes a relationship, and finds a solution to the problem with the data it collects (Sanders & Stappers, 2012). Focusing on the early-stage activity and developing solutions (Kokotovich, 2007) is the most challenging stage for novice designers.

Mathias (1995) found that, novice designers have no Problem Analysis (exploration of the problem area) in their processes compared to expert designers. Cross (2004) calls this 'scope of the problem' based on a focused or directed approach to collecting and prioritizing data about the problem area. Experts spend more time dealing with data and include them in their design ideas, novice designers tend to embody the data in the design problem area independently (Mathias, 1995).

Data alone is not useful nor applicable and the creative. Students obtain knowledge by interpreting this data and jumping from raw data to insight by synthesis. This is a difficult skill to learn, and different methods should be developed to help students (Kolko, 2007). So, it is important to support design students to experience the problem structuring process in projects with different methods and techniques.

Systematic Design Process

The DP that starts with the definition of the problem, reveals the problems, and ends with the solution (Açıcı, 2015) is a set of chronological and repetitive activities (Asimov, 1962; Bayazit 2004). From the perspective of design and technology education, the DP generally includes the steps of identifying a problem, undertaking research, generating plans of solutions, producing solutions, and evaluating the solutions (Middleton, 2005). Lawson (2005) states that the DP is infinite, prescriptive, and subjective activity carried out to meet a need. However, Selau (et.al,2020) points out that design should be an independent process from the persons.

'Design Methods Movements'(DMM) were initiated in 1950s and 1960s with the support of governments to conduct studies based on descriptive stages to define the complex DP. (Alexander, 1964; Cross, 1986; Jones, 1965; Rittel and Webber, 1973; Gedenryd, 1998). The purpose of the DMM is to understand the DP and to make it less dependent on the art and the designer. Governments have led researchers to more systematic processes within the scope of DMM. The oldest model that defines design as a systematic activity is the 'system' or 'task-oriented' approach applied by NASA (Rittel and Webber, 1984). The DP stages developed by different researchers generally as follows, understanding and defining the problem, collecting data, analyzing data, developing concepts for alternative solutions, evaluating alternatives, and choosing, testing, and applying solutions (Selau et.al, 2020).

In the 1970s systematic DP models were developed. The ‘Systematic Approach’ is a prescriptive model and developed by Pahl and Beitz in 1974. According to this approach, after each stage, which can be iterative, the 'decision-making stage' is carried out to evaluate the stage results, repeat the stage or move on to the next stage (Kannengiesser and Gero, 2017).

While Rittel and Webber (1973) describe the DP as a rational research task, Schön (1983) defines it as reflective practice. Archer's (1965) DP model is objective and rational (Herr, 2008). Archer’s model (Figure 1), which also includes the training and experience of the designer emphasizes the importance of data collection in the DP while stating that designers should return to the data collection stage when needed after other stages. The emphasis Archer attaches to the data collection stage is the designer's or engineer's intuition or custom and practice (Davis and Gristwood, 2016).

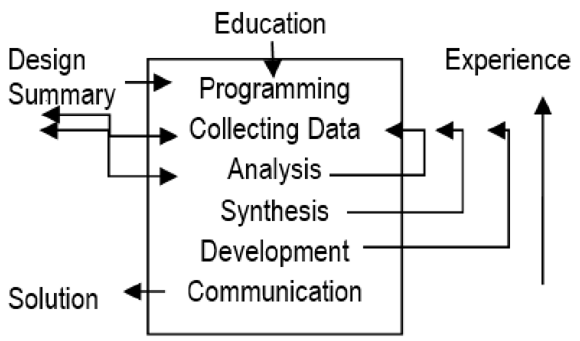

Figure 1. Archer DP (Cross, 2008)

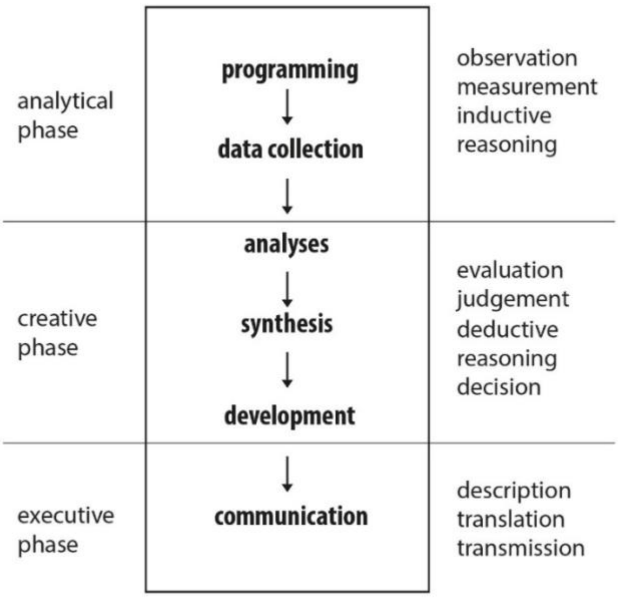

Figure 2. Archer Systematic DP Model (Cross, 2008)

Archer's systematic model to achieve the targeted design result (Aktaş and Çolakoğlu, 2018) is grouped as analytical, creative, and executive phase (Figure 2). In programming, the problem is defined, important points are emphasized, a business plan is made. Data is collected and organized during the data collection phase. In the analysis phase, sub-problems are determined and the product requirements, production problems and priorities are determined. In the synthesis where design ideas are produced, the suitability and applicability of the ideas are checked. The problems that need to be solved for the design idea to be implemented in the development phase are discussed. In the communication, the necessary drawings are prepared for production. In the DP model proposed by Archer, systematic observation and inductive reasoning are used in the analytical stage, while subjective and deductive reasoning is used in the creative stage (Linden et.al, 2011).

The DP stages in which different approaches are shown in Table 1 under the headings of early and late design phases. The number and terminology of the stages used to define the DP models are due to the professional design areas in which individuals are involved (Cross, 2008).

Table 1. DP Models (Oygur, 2012)

	DESIGN PROCESS	
	EARLY PHASE of DESIGN PROCESS	LATE PHASE of DESIGN PROCESS
Archer (1984)	Programming > Data collection —> Analysis —> Synthesis	Development —> Communication
Pahl and Beitz (1974)	Clarification of the task — > Conceptual design	Embodiment—> Detail design
Schön (1992)	Identification of Design problem —> Decision—> Reflection	Result

Early design Phase 'Fuzzy Front-end': The conceptual DP

The early phase of the DP is ill-defined, while the late phase of the design is better defined (Sturges et.al, 1993). The early phase focuses more on creativity (Snider et.al 2014). While the early phase is shown as the most efficient process for the development of innovative ideas (Figure 3), it is also stated that the necessary data should be collected to make effective and efficient decisions in the innovation process (Herstatt and Verworn,2004).

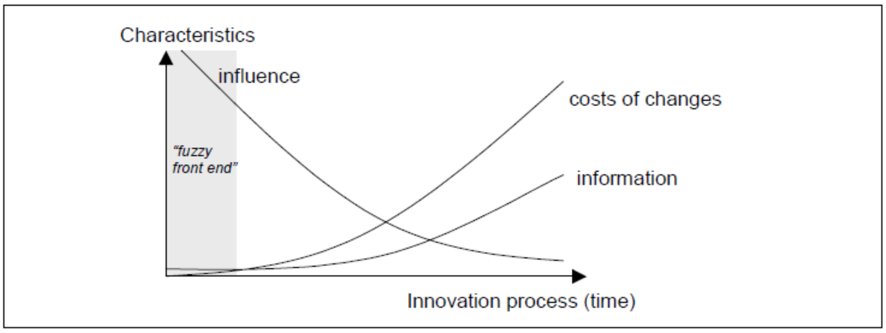

Figure 3. Early Phase and Innovation (Herstatt and Verworn, 2004)

The early phase of the DP is the front end of the design activities in which the design problem is defined (Cagan et al., 2002; Sanders and Stappers, 2012). CD completed in the early phase period defined as 'fuzzy front end' has the most important effect in the DP (Grierson and Khajehpour, 2002). However, the 'fuzzy front end' is the least structured phase, both in theory and in practice, and there is a need to systematize activities to increase efficiency (Herstat and Verworn, 2004). A structured process has a positive effect on student achievement (Radcliffe and Lee,1989).

CD is the most important part of a project (Gharib, 2016), dynamic and creative phase, it is the most difficult and least understood (Macmillan et.al, 2001). Good CD means innovation, and an innovative design comes about when one deliberately tries to create one (Perkins, 1981).

Inquiry-Based learning in the conceptual design process

CD in which data collection and development of design idea is critical and is the most difficult process for students. Because the student does not know what to do and how to reason with the data obtained. Critical thinking on collected data at the early stage has a significant impact on the next stages. (Björklund, 2013).

Students should be in inquiry-based learning (IBL) style to develop their critical thinking skills. IBL is based on the philosophy of Dewey (1986), which states that education begins with the curiosity of the learner and then is the activities corresponding to learning and research. IBL is a student-centered active learning approach where the students are part of the whole research process (Herzog et.al, 2016).

IBL activities start with the creation of a research question and continue with research and development of solutions (Herzog et.al, 2016). Students create new knowledge based on the data they have within the scope of the research question. Generating new knowledge is an important part of the learning process and at the end of the process, the findings are presented (Herzog et.al, 2016, Mieg, 2019).

Wildt (2009) combines the IBL model with the Kolb learning model and describes research and experiential learning as follows:

> *The research and the learning process start with observation of problems in the real world and the concrete experience, the students are irritated by a situation or an experience. The defining of questions or problems is part two of the cycle (reflective observation) and ends with the formulation of research questions or hypothesis. The abstract conceptualization is used to develop a research concept and design. The developed concepts will be verified during active experimentation and new knowledge will be created. From these findings new learning and research cycles start. (Herzog et al., 2016).*

Kolb's Learning Style Inventory is the most widely used model for design students due to its generalized and reliable structure (Carmel-Gilfilen, 2012; Demirkan and Demirbas, 2008). According to Kolb's model (Figure 4), a learning cycle consists of four stages: concrete experience (CE) reflective observation (RO), abstract conceptualization (AC) and active experimentation (AE). Design students are in the active learners group. He argues that learning begins with experience, continues with reflection, and then becomes a concrete experience in reflection (Kolb, 1984).

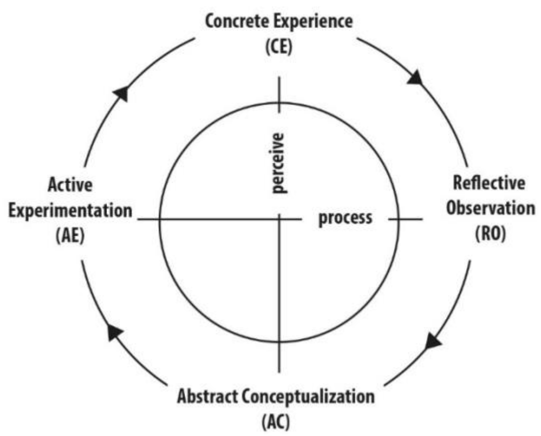

Figure 4. Kolb ELT Phases (Demirkan and Demirbaş, 2008)

Students can reveal a relationship between the obtained data and the new knowledge with IBL through research, in other words, the cause-effect relationship. Cause-effect express the relationship between two phenomena caused by one phenomenon behind another (Salkind, 2010).

As the above discussion proves, it is concluded that a new methodology that combines the conceptual DP with an IBL model and contributes to students' professional skills can be useful in design. Guided questions encourage critical thinking about aspects of the problem that need to be addressed to develop a successful design.

Design for the disabled

Disability is the condition of preventing one's full and effective participation in society on an equal basis with others, due to imperfection (lack of psychological-physical functions), dysfunction (inability to work compared to a healthy person) and disability (inability to perform normal activities due to disability) (Koca, 2010; WHO, 2011; Börklü et.al, 2018), or long-term physical, emotional, mental or sensory impairments (CRPD, 2020).

Design for the Disabled is defined with the terminologies' Universal Design ', Accessible Design', 'Barrier-Free Design', 'Design for All' in the fields of architecture and design, and it is aimed to make more inclusive designs. Universal Design means the design of products, environments, programs, and services that can be used by everyone without the need for special design (UN Human Rights, 2020).

Industrial designers are expected to take responsibility for the disabled, the homeless, and the unemployed, as well as designing products for profit (Papanek, 1995; Yavuzcan et.al, 2019). Norman (2009) also reveals the lack of education by stating that the disabled are not a small group deprived of their rights and represent all individuals, therefore what needs to be done is education, awareness, and empathy.

Apart from the concept of accessibility in physical environments, social, emotional, cognitive, and physical needs of persons with disabilities should be met within their skills and abilities. Considering these requirements, the terminology 'Design for Disabled' has been used to prevent the project from being accessibility oriented.

Methodology - Conceptual DP with IBL

According to the discussions, auxiliary toolkits are required for students to learn the conceptual DP defined as 'fuzzy front end'. Therefore, a toolkit focused on IBL learning that can be used in teaching the conceptual DP has been developed. Fourteen students attending the Gazi University 2019-2020 Distance Education Academic Year Fall Semester Design for Disabled course, were asked to use new teaching toolkit. This toolkit consists of the CD Learning Tool and its Matrix. The main purpose of the toolkit is to guide design students to develop design solutions consistent with the design problem and develop critical thinking skills by learning the conceptual DP defined as the 'fuzzy front end' of design with a systematic and inquiry-based structured toolkit. The new tool developed encourages critical thinking about the aspects of the problem that need to be addressed to develop a good design idea, with guided questions in the process stage.

The new learning tool (Figure 5), Archer systematic design model (Cross, 2008), IDEO Design Thinking, Scientific Project Stages, City of Toronto Accessibility design guidelines, 5W1H tools used in scenario and fiction development, and lecturers' self-knowledge were created. The Archer model and the IDEO Design Thinking model cover the entire DP and research questions are omitted. The City of Toronto Accessibility design guide focuses on 'Accessibility', hence the physical barrier. 5W1H research questions are mostly used in developing scenarios and fiction.

Systematically structured New CD (Figure 5) guide consists of 3 main phases and 8 consecutive steps: Analytical Phase (Programming, Data Collection), Creative Phase (Primary Analysis, Secondary Analysis, Synthesis, Hypothesis), and Visualization Phase (Preliminary Design, Final Design). A New CD Matrix (Figure 6) was created by using the New CD tool for the students to process the decisions they make in each step. Students were asked to develop projects with this process matrix.

The content of each stage in the newly designed CD learning tool is detailed in Figure 5.

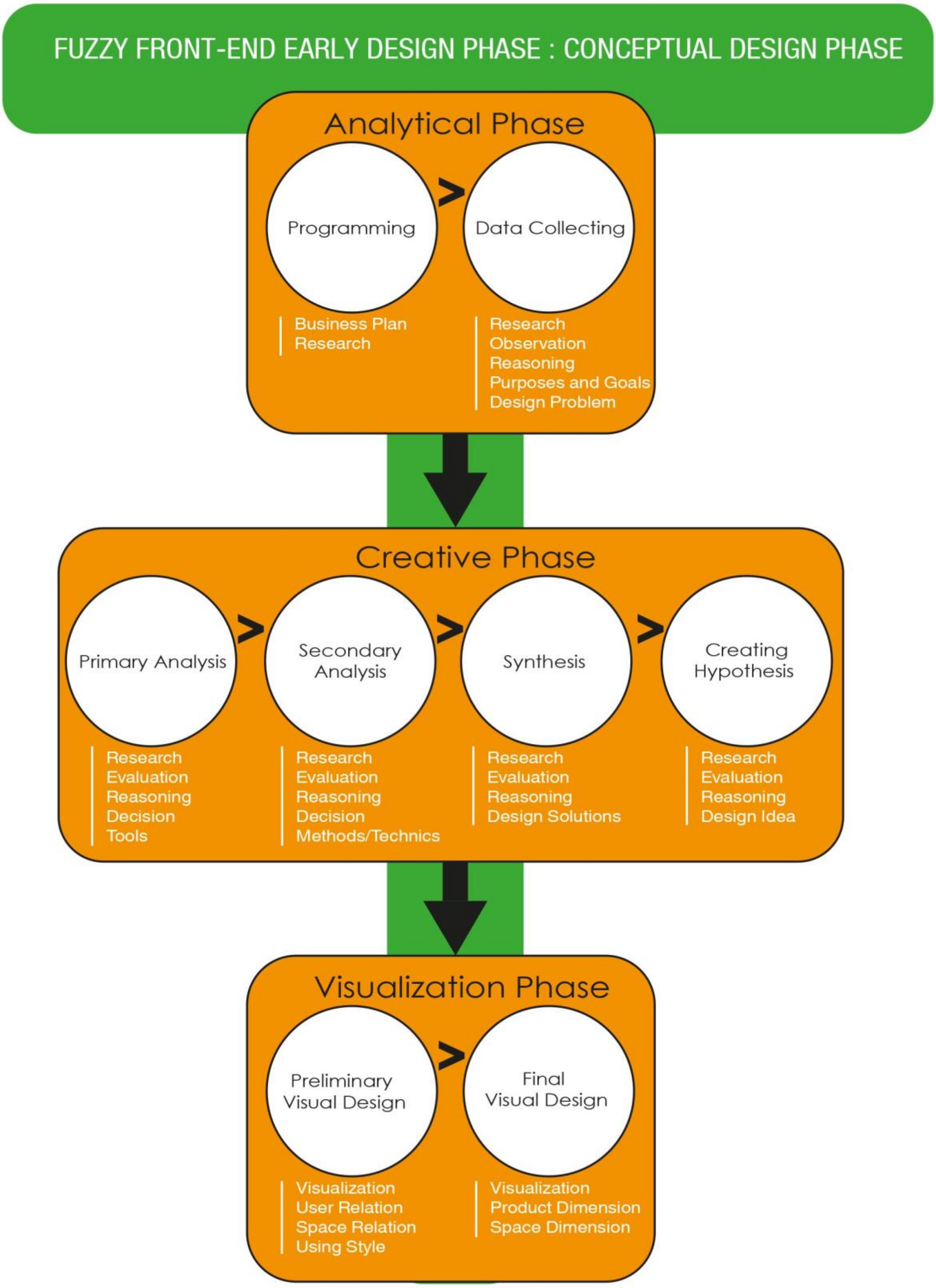

Figure 5. Teaching Fuzzy Front-End and Early Phase of Design: Systematically Structured Phases of The New Teaching Tool for Conceptual DP

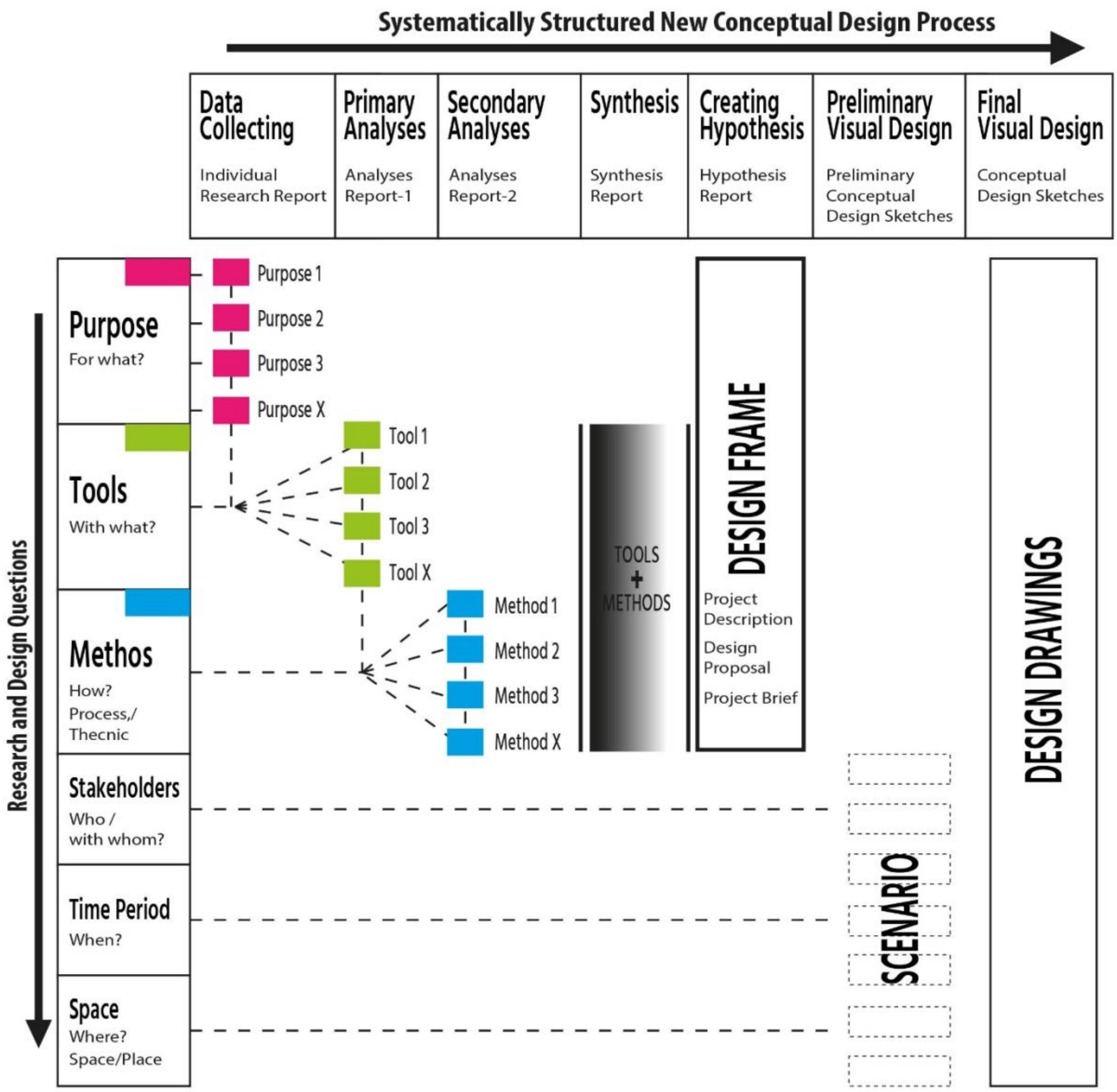

Figure 6. The New Inquiry Based Teaching Matrix for Conceptual DP

Project Topic: Conceptual Design Project for Individuals with Disabilities

Individuals with disabilities are grouped as physically, mentally, hearing and visually impaired. 12 weeks of the 14-week course process were conducted through online platforms during the Covid-19 Pandemic. During the project, critical lessons were carried out synchronized online, while a project management online curriculum application was used for the recording of students' activities. The students uploaded the report of each project stage they developed for the disability group they chose, on the application.

A design brief was presented to the students as a guide that conveys the form and content of the reports they need to upload at each stage in detail. The reports submitted by the students at each stage, were criticized by the lecturers. After the student's report was found sufficient, the students added their decisions on to the process matrix. If the student's report was not sufficient the student was asked to repeat stage.

Using an online application, students were able to follow and examine each other's projects and processes.

Analytical Phase

It is the phase in which the students are asked to define the problem their designs will address. This step is important as it drives the rest of the DP and determines how project success will be measured.

Programming

At this stage, a business plan related to the education and training process was created and a guide was presented to the students. The contents of programming are specified in the following 2 titles.

Guidelines for the Design for the Disabled

At this stage, a design brief was prepared by the lecturers to guide the students, the presentations of the expected studies and the duration of the stages were shown.

Design for Disabled: Disability Group Selection

Before choosing the groups, for guidance, students be given the 9th and 30th articles of the United Nations Convention on the Rights of Persons with Disabilities (2020), an international human rights convention to protect the rights of the disabled. Students were asked to obtain information about contents of these titles (Table 2).

Table 2. Articles of the Contract (UN Human Rights, 2020)

Article-9 - Accessibility
Article-10 - Right to lifeArticle-11 - Situations of risk and humanitarian emergencies
Article-12 - Equal recognition before the law
Article-13 - Access to justice
Article-14 - Liberty and security of the person
Article-16 - Freedom from exploitation, violence and abuse
Article-17 - Protection of the integrity of the person
Article-18 - Freedom of movement and nationality
Article-19 - Living independently and being included in the community
Article-20 - Personal mobility
Article-21 - Freedom of expression and opinion and access to information
Article-22 - Respect for privacy
Article-23 - Respect for home and the family
Article-24 - Education
Article-25 - Health
Article-26 - Habilitation and rehabilitation
Article-27 - Work and employment
Article-28 - Adequate standard of living and social protection
Article-29 - Participation in political and public life
Article-30 - Participation in cultural life, recreation, leisure and sports

After choosing the disability group the students examined the population distribution and demographic structures according to the groups.

Data collecting

Format: Be asked to present the data obtained in line with their literature reviews as an individual research report, to have a list of sources in the last part of the reports, and to refer to the relevant sources in the text in accordance with the APA format. The reports were uploaded to the board by the students.

Content: Universal design, accessibility in public spaces, ergonomics, design criteria, social services, spaces, events organized for the disabled, the problems and difficulties experienced by the disabled are the research topics. During the data collection, students who could not meet with users due to Covid-19 Pandemic were asked to benefit from previous written and visual scientific research to get their opinions on the problems and experiences of the users. They were able to use all kinds of written, visual, and video resources reflecting user opinions and experiences. They were asked to present written and visual research summaries of the literature on systems and technologies, communication, and social relations for people with disabilities, examples of space and product design, standards, and regulations for disabled, and surveys and analyses related to their research. Students were asked to collect data on the studies and products, services and systems carried out according to the United Nations Convention on the Rights of Persons with Disabilities (2020). The reports were asked to reflect the summaries of the literature and to analyze the technical data obtained. Finally, they were asked to present their answers to the research questions.

Research Questions: At the end of the data collection phase, the reports were completed by defining the design problem, objective/objectives, and goal/goals. What are you designing for? What is your design goal/purpose? Attention has been paid to ensure that the design goal and purpose, which directly shows the design emphasis is clear, measurable, realistic, and accessible during the project period.

Matrix Processing: The answers to the research questions are converted into keywords and entered in the matrix.

Students who could not fully define their goals and objectives repeated the stage.

Creative Phase

In this phase the student develops tools, methods, design solution and design idea for the design problem.

After the problem is determined, students continue to do research with written and visual tools. Then, students work on possible design solutions.

They are expected to draw their design ideas with diagrams or maps and communicate why they developed that design idea. The design idea is expected to be consistent with the design problem.

Primary Analysis

Format: For the continuity, the research was presented in a report with both written and visual content.

Content: During the data collection phase, the data provide possible solutions to the design goal. The students were asked to deductively analyze the tool(s) that will enable them to achieve their design goals and analyze the structures and relationships.

At this stage, they have investigated the tools with which they could achieve their design goals. This tool could be an object, a social or a physical activity. Students do not have to do research focusing on people with disabilities. User demand analyses were requested. The students were asked to do their research in line with the experiences and social or physical activities that could be a solution to the design problem, considering the competencies of the disability group within the framework of the design goal they determined. Finally, they were asked to present their answers to the research questions.

Questions: Which tools can you use to reach your design goal? What are the tool(s) required to achieve your design goal?

Matrix Processing: Entering into the matrix as primary analysis question-answer key definitions. Students can write more than 1 tool.

The students who could not fully define the necessary tools to achieve their goals and objectives were asked to repeat the stage.

Secondary Analysis

Format: For the continuity, the research was presented in a report with both written and visual content.

Content: At this stage, the students were asked to research the methods, processes and techniques they will apply while using the design tools they have determined. They were asked to analyze structures and relationships with deduction.

At this stage, they researched design methods in line with design goals and design tools. This method can be an action or a known technique or process. Students do not have to do research focusing on people with disabilities. In the primary analysis phase, the students were asked to conduct research, within the framework of the design goals and tools they determined. Finally, they were asked to present their answers to the research questions.

Questions: Which method/technique/process do you plan to implement to achieve your design goal? What are the methods required to reach your design goal?

Matrix Processing: Entering into the matrix as secondary analysis question-answer key definitions. Students can write more than 1 method.

In the Secondary Analysis stage, the students who could not fully define the necessary tools to achieve their goals and objectives were asked to repeat the stage.

Synthesis

Form: Students prepared a report with original written and visual content in the continuation.

Content: This stage is the summary stage where the primary and secondary analysis data are defined. One of the tools and methods that are in a cause-effect relationship towards the goal was asked to be selected and declared. It was asked to define which user needs it could meet by combining the decided tool and method. In the conclusion part of the report, they were asked to present their answers to the research questions.

Questions: How do you plan to reach your design goal (method) and what will you use (tool)?

Matrix Processing: The selected tool and method were entered into the matrix.

If the tool and method was not consistent within the framework of cause-effect relationship, students were asked to repeat the stage.

Creating Hypothesis (Development)

Form: In the continuation, the original reports were asked to define the project in writing and to transfer their definitions using drawings, graphics, storyboard, animation, scenario map, user map, system map.

Content: It is the stage where new and original assumptions are put forward, it is the design framework. Design is the first stage in which solutions turn into an idea and the design idea is developed. The students were asked to develop a design idea of a product or a space within the scope of a tool and a method that was combined for a purpose and a target. Finally, they were asked to present their answers to the research questions.

Questions: What's your design idea?

Matrix Processing: Entering design ideas into the matrix.

A step repetition was requested for design ideas that did not include previously determined tools and methods.

Visualization Phase

The design idea is visualized, and design sketches are made. Finally, it is requested to work on determining the dimensions, the choice of material, color, and texture.

Preliminary Visual Design

Form: In the continuation, sketches were requested.

Content: It was requested to transfer the fiction and scenario including the stakeholder, place and time period of the created hypothesis. It was requested to design the user relationship and preliminary form.

Matrix Processing: Visually entering projects into the matrix.

Final Visual Design

Form: In the continuation, sketches were requested.

Content: It was requested that the preliminary designs be detailed in terms of product-space, product-user, space-user relationship. It was requested to determine the dimensions for the product or space, and to review the preliminary designs of the form according to the measurements.

Matrix Processing: Visually entering projects into the matrix.

Stage Evaluation
Students who successfully completed each stage with clear answers were asked to enter their decisions into the matrix and they were asked to be prepared for the next stage. The students who were not consistency and clear were asked to repeat the stage aligned with the given criticism.

Project management
Stage contents and timing of the students were important to manage the project. The stages and timelines are shown in Table 3.

Table 2. Reports and Timelines

Project Phases	***Week***	***Reports***
Analytical Phase	*1*	*Business plan*
	1-2	*Data collection* (Determining Goals and Targets, Defining the Design Problem)
Creative Phase	*2-3*	*Primary Analysis (Identifying Tools Towards the Design Problem)*
	3-4	*Secondary Analysis* (Determining the Methods Regarding the Design Problem)
	4-5-6	*Synthesis* (Determining the Design Solution for the Design Problem via Tools and Methods)
	6-7-8	*Hypothesis* (Conversion of Determined Design Solutions into Design Ideas)
Conceptual Visualization Phase	*8-9-10*	*Preliminary Design* (Fiction of Design Idea, User Relationship and Visualization Studies)
	9-10-11	*Final Design* (Determination of the Dimensions of the Visualized Design Idea, Applicability)
	12	*Jury Evaluation* (Presentation of the Matrix and Project)

Evaluation of Projects
Finally, each project was evaluated by 3 lecturers according to the criteria the level of qualification in the Likert scale. The qualitative evaluations used instead of points in this study are shared in the results section.

Analysis of Projects and Process Observations

Lecturers used a rubric consisting of criteria determined according to the learning outcomes to evaluate projects. Evaluation criteria were in 2 parts as process and project. Process evaluation criteria are project management, critical thinking skills, report presentation quality. Project evaluation criteria are consistent cause-effect relationship, presentation quality, effective communication skills, holistic design approach, originality, and innovation. The common observation findings of the lecturers for each project were conveyed as analytical phase, creative phase, and visualization phase.

The expected learning outcomes at the end of the newly developed Conceptual DP methodology stages are stated as follows:

- Being able to read written and visual data,
- Developing critical thinking skills (analysis, synthesis, evaluation),
- To conduct evidence-based research, to develop a meaningful product concept,
- To be able to create consistent cause-effect relationships between the design problem and idea,
- To grasp the conceptual DP,
- Developing project management skills,
- Developing effective thinking, speaking, and writing skills,
- To create awareness on Design for Disabled.

Post-project questionnaire

Questionnaire completed by instructors: A rubric was asked to 3 lecturers to calculate the mean values of the subjective evaluations (project evaluations).

Questionnaire completed by students: It was developed using the Likert scale to get feedback from students about the effectiveness of the new teaching model developed to better learn the conceptual DP defined as the fuzzy front-end. The questionnaire was applied to all the class and answered by all of them.

Results

Fourteen students attended Gazi University 2019-2020 Distance Education Academic Year Fall Semester Design for Disabled course. It can be said that the new teaching tool developed with the students developing projects according to different disability groups is applied for different projects. In this study, projects that constantly participate in the course and fulfil the tasks determined at each stage are presented. Then, the results of the questionnaire were administered by the fourteen students and finally the evaluations were made by the lecturers according to the criteria.

The lecturers made the examinations in 3 stages. These stages are listed as analytical (programming and data collection) (1), creative (primary and secondary analysis, synthesis, hypothesis) (2), conceptual visualization stage (preliminary CD and final design) (3). The findings below are made in the order given.

Project-1- Judo Education and Play Material for Visually Impaired Children

Student who chose the subject of design for visually impaired individuals were grouped under 3 headings as ‘facilitative designs for reading-learning, psychological/social themed research and physical barriers encountered in the environment’ and it was concluded that the least number of studies were on Psychological and Social themes. The student has chosen to work on 'Article-30 - Participation in cultural life, recreation, leisure and sports’. The student categorized the visually impaired individuals according to their demographic characteristics and conducted research on their needs and problems. It was found that one of the problems faced by visually impaired individuals is balance and it is mostly encountered in children between the ages of 5 and 10. So he decided on the concept of balance as a design purpose. The student defined the design problem to solve the balance problems of visually impaired children in the 5-10 age group.

The student continued to research and analyze the design goal of the balance problem. He avoided doing his research only on visually impaired individuals. He utilized scientific research on the balance problem that can be encountered in every individual. At this stage, the student asked 'what' and 'which vehicle' questions to achieve the design goal. He found that some sports, especially judo, have important and positive effects on balancing. In the secondary analysis phase of the research, he sought answers to the questions of ‘how’, ‘which method/technique/process’ to achieve the design goal. He reached the data that children in this age group learn best with games, toys or in social settings. He found that the best way of learning for visually impaired individuals is from piece to whole.

When the student reaches the synthesis stage, the basic concepts that he obtained are balance, judo, game/toy, social learning, and puzzle. He developed a new judo training solution through a game/toy aimed at the student design goal.

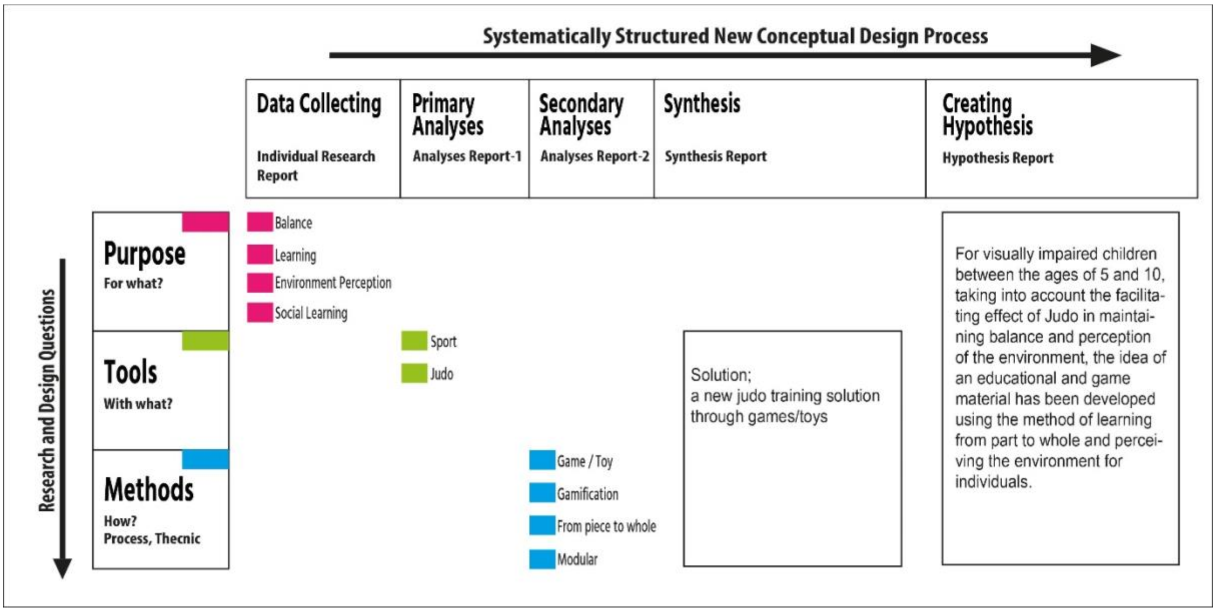

Figure 7. Project 1 Matrix

In the development phase, considering the facilitating effect of Judo in maintaining balance and perception of the environment, the idea of an educational and game material has been developed using the method of learning from part to whole and perceiving the environment for individuals. He drew and studied the basic movements of judo and worked on wearable parts that were compatible with the movements. A new judo learning model has been developed by combining games, education, and judo in this designed product group. In the first stage of the training, individuals use training and game materials to practice perception and matching by touching. While the mathematical skills of individuals are improved with the modular units where the Braille alphabet numbers are imprinted, the perception of touch is improved by matching the modular units where different textures are embedded. Individuals who complete this stage move to judo training. At the end of the second phase, the student developed a new idea of judo training and educational material design to help balancing issue of the visually impaired children.

In the last phase, the student visualized the design idea and assembly. The product group designed for a judo learning model that can be used for one person or two people consist of a judo mat, arm baguette and wearable units. The judo mat consists of textured and smooth modular units that assist in placing the feet in correct positions while learning steps. The judo baguette, which is designed for short and long-distance arm movements, allows users to perceive the limits by units placed on it. Wearable units for shoulders, elbows and knees allow the user's perception of the right move towards the opposite player by the triangular units on them.

The matrix of the project is shown in Figure 7.

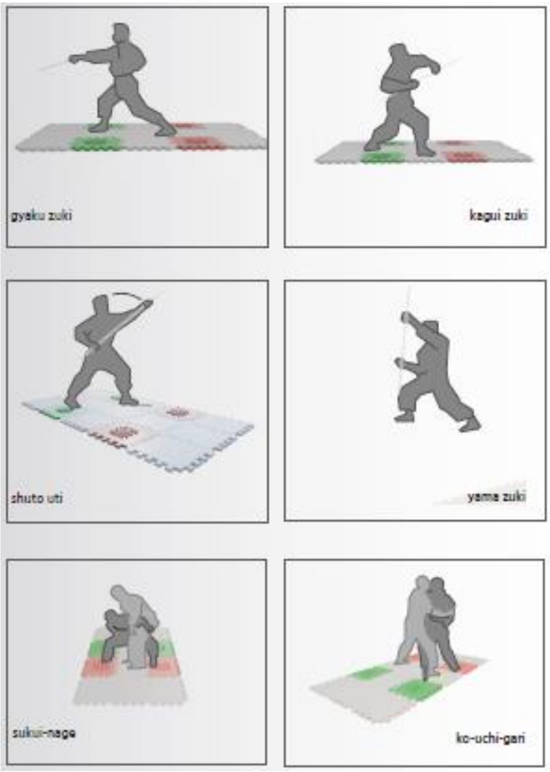

Figure 8. Project 1 Preliminary Design Phase

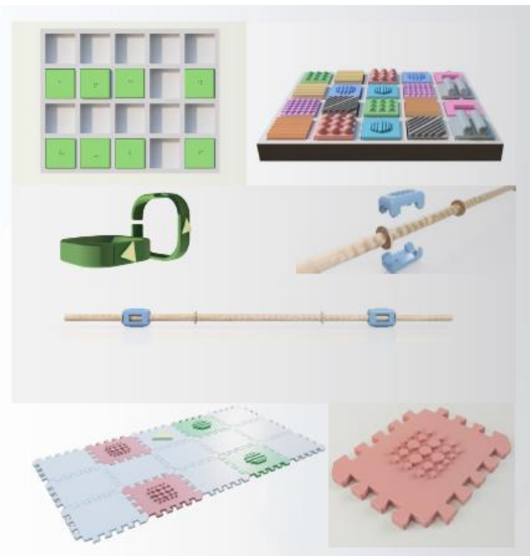

Figure 9. Project 1 Final Design Phase

Project-2- Acoustic Exhibition Area Design for Visually Impaired

The student has decided to work on 'Article-30- Cultural life, recreation, leisure and participation in sports' to design for visually impaired individuals. The student categorized the visually impaired individuals according to their demographic characteristics and conducted research on their needs and problems. He reached the data that one of the biggest obstacles for visually impaired individuals is to socialize and participate in various cultural activities due to navigating problem. The student defined the difficulties visually impaired individuals experience in navigating to socialize as a design problem.

The student reached the examples indoor and outdoor spaces. It has been determined that the samples developed only help them find direction and do not contain any social experience. Within the scope of Article-30, the student defined exhibition areas as a means for disabled to socialize. Thus, the student worked on interior spaces where they can have social and cultural experience by using space and product together. The exhibition area designed for the visually impaired has been functionalized with acoustics and building elements. There is a space design with a U-shaped circulation structure dominated by concrete and glass. Users enter the venue, take their headset from the box office at the entrance, and then proceed in the direction of circulation and perceive the work of art placed with a 60-degree slope by touching.

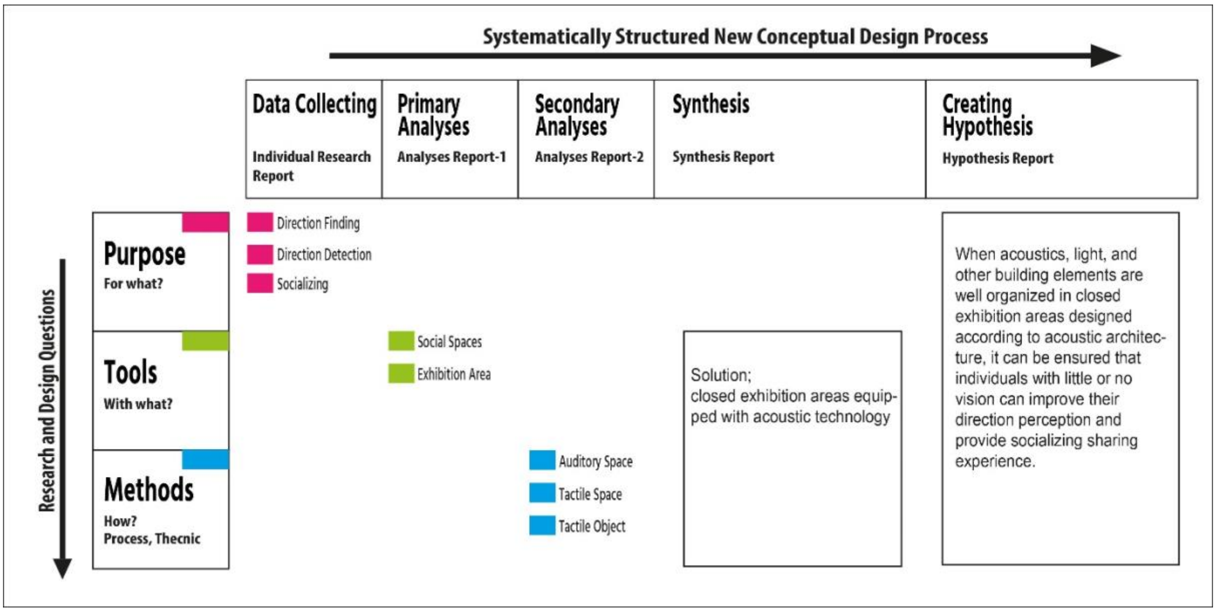

Figure 10. Project 2 Matrix

In the third phase, the student visualized the fiction between space and product, designed product-space physical relationship, materials, and measures. Visually impaired and healthy individuals are guided in the space by headphones that are integrated with the central sound system. The glass, which is used as a reflective surface on the exterior, also provides contrast lighting for individuals with low vision. There are tactile surfaces on the floor to guide users in the direction of circulation. He tried to analyze architectural elements, light, sound, and building.

The matrix of the project is shown in Figure 10.

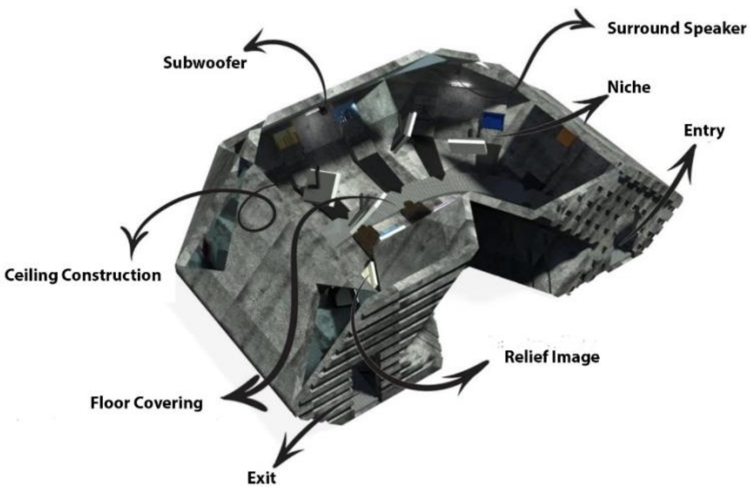

Figure 11. Preliminary Design Phase of Project 2

Project-3- Learning with Social Story for the Mentally Disabled

The student who chose the design subject for mentally handicapped individuals decided to work on ['Article-24 - Education'](), one of the contract articles in the first phase. In the researchers conducted for the mentally disabled, the student found that the parents of disabled children had difficulty in their behavioral training. These behavioral disorders are listed as follows:

1. Solving problems experienced while traveling on foot (leaving the mother's hand while crossing the street and running),
2. To explain not every desired object can be taken,
3. It aims to reduce the overreaction to change.

The student developed a project for these problems.

The student researched the tools and methods that could be used to increase the learning levels of individuals. The student has reached the data showing social stories used to help children with intellectual disability to help them gain daily life skills. However, these social stories were presented as written sources supported by visuals. The student formed the knowledge by thinking critically that the social stories presented in books could not be up to date. The student reached the data that these individuals learn best by mirroring and taking someone as an example (model-based learning). He tried to establish a relationship between the social story he wanted to use in his project and to find a design solution to bring learning and mirroring. However, the student aimed to use digital technologies to keep social stories up-to-date and use them easily in every environment. Within the scope of the project, a digital product with an animated didactic social story and a physical product used to remind the information learned through stories were designed for individuals with mild mental disabilities such as autism. Basically, the digital product aims to convey the correct theoretical information to individuals through animation, to show the results of the elections again with animation; the physical product aims to remind the theoretical knowledge learned in real life. The physical product can be used both in mobile and stationary places.

The student conducted research on the characters and colors that should be used for these special individuals. He designed an animation by developing all the characters and interfaces according to the story he fictionalized. The student designed 3 stories containing successful characters and fiction due to his special interest in the field of illustration. The matrix of the project is shown in Figure 12. The editing and contents of the stories are shown in Figures 13 and 14.

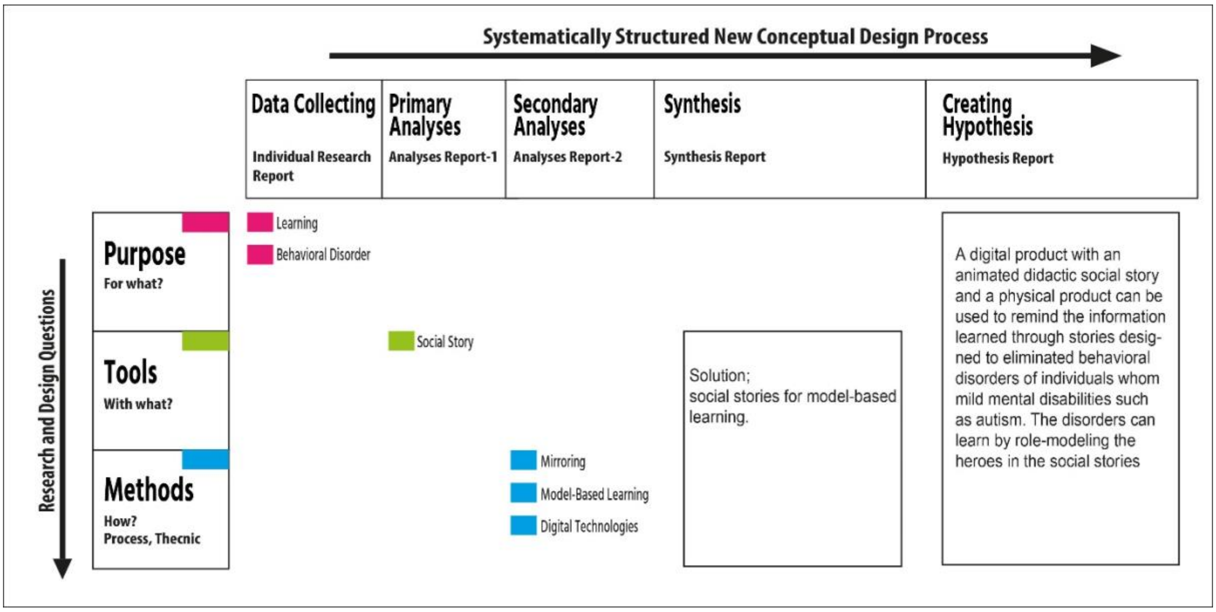

Figure 12. Project 3 Matrix

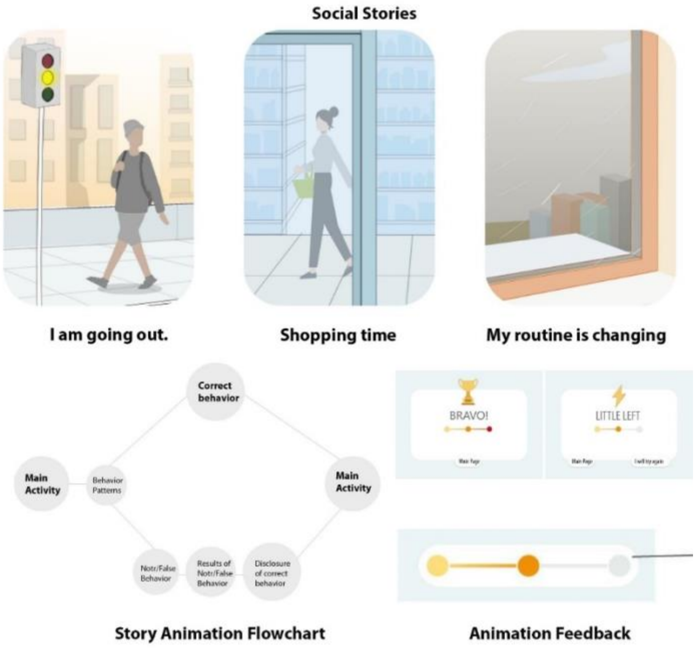

Figure 13. Project 3 Preliminary Design Phase

Figure 14. Project 3 Final Design Phase

Project-4- Gardening Area and Equipment Design for Physically Disabled
The student decided to work on one of the contract clauses 'Article 26- Habilitation and rehabilitation' in the first phase and design subject for physically disabled individuals. The student searches on the rehabilitation needs of physically disabled individuals and determined socialization and rehabilitation as the design goal.

Through the studies on the rehabilitative effect of soil, one of the rehabilitation tools, the student researched the hobby gardens. Hobby gardens are areas where people can relate to nature, relax, and spend time in their surroundings. In line with the literature, the horticultural therapy method used in the project includes the disabled individuals' activities with soil and nature in the garden. Therefore, the student presented the definition of an agricultural area, agricultural system and agricultural facility and the method he would use in his design idea. It is primarily aimed to plan the area where they can be active together on farm and to develop agricultural units and systems suitable for those individuals to get away from the stress of the city and spend time in gardens. A social facility including a parking lot for the disabled, a common social area and a business office is planned. The matrix of the project is shown in Figure 15.

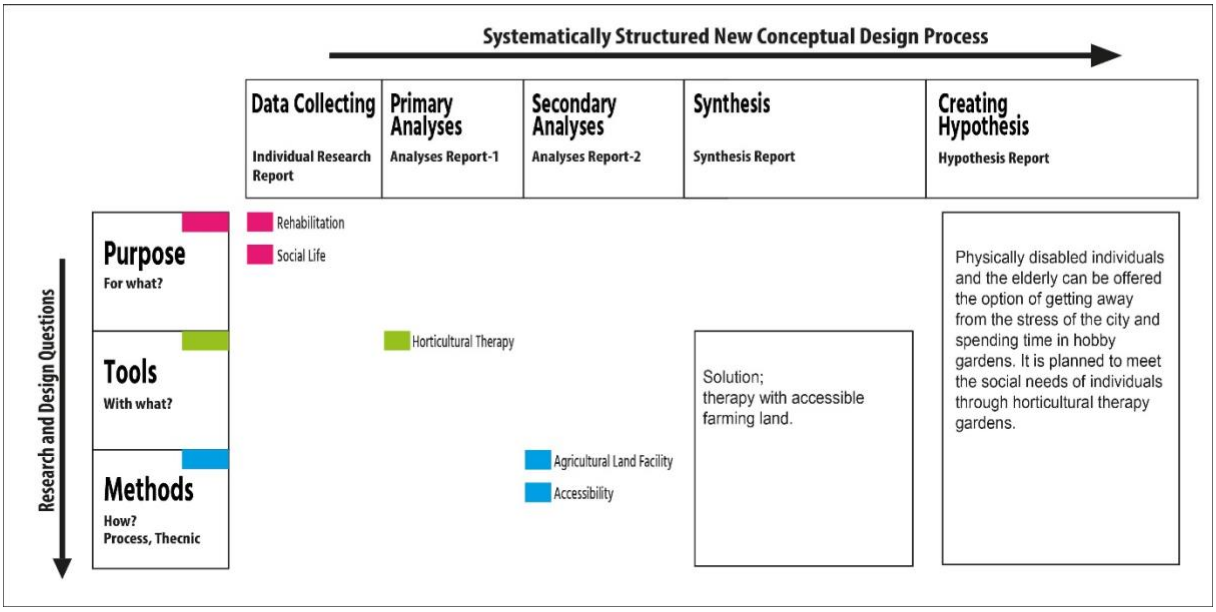

Figure 15. Project 4 Matrix

In the third phase, the student worked on ergonomic and agricultural system units. There is a user in each agricultural unit in the agricultural facility, units are protected by pergola which is also used for stacking garden tools. Ergonomic and functional solutions have been developed to provide easy access to root crops and other plants in agricultural units. Vertical opening lids in the units are used for soil, fertilizer, etc. horizontally opening lids are designed for the cultivation of underground plants (potatoes, onions, carrots, etc.). Rainwater flowing into the PVC pipes attached to the roof passes through the drainage pipe and reaches the storage under the agricultural units. In common areas, it was envisioned that individuals socially interact during rest and breaks and engage in cooking activities using fresh produce from their gardens. The preliminary and final design phases are shown in Figure 16 and Figure 17, respectively.

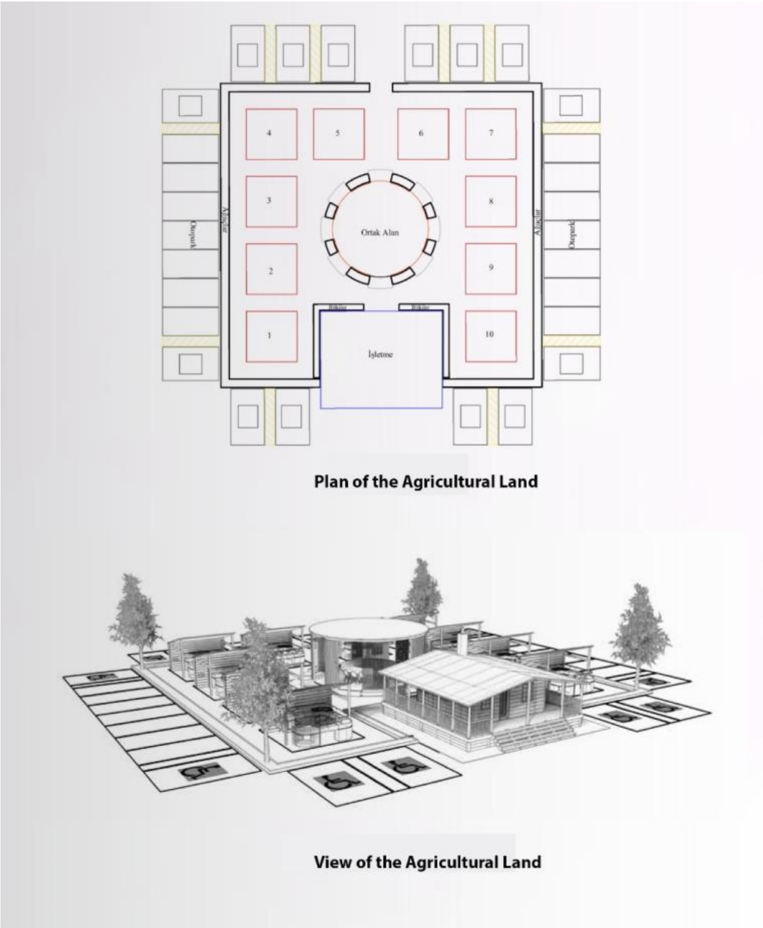

Figure 16. Project 4 Preliminary Design Phase

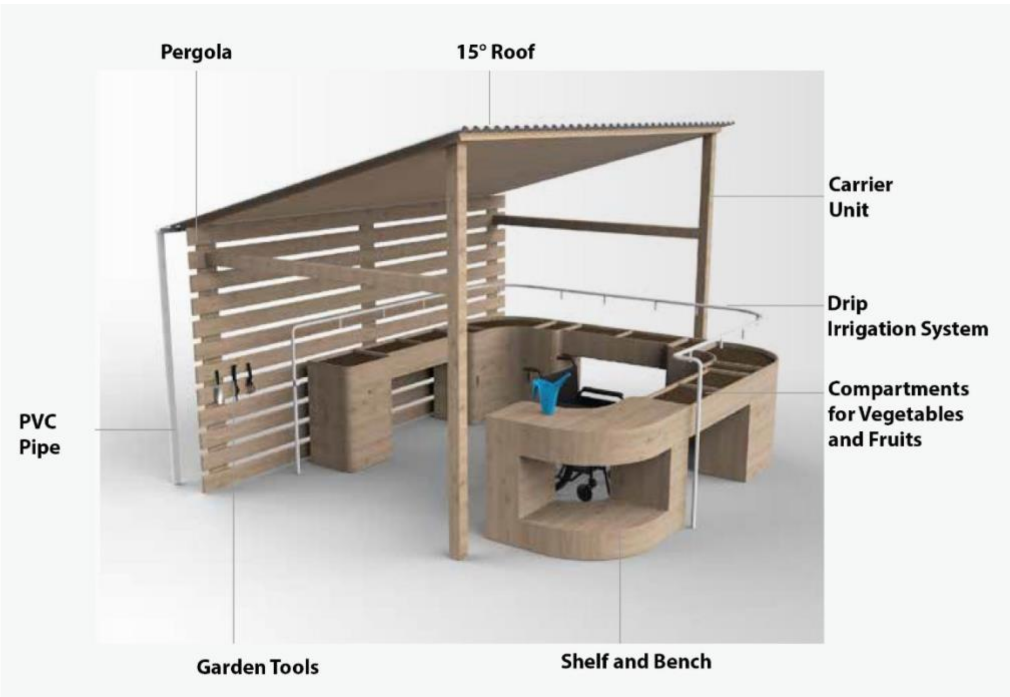

Figure 17. Project 4 Final Design Phase

Post-project student questionnaire

Students were asked to evaluate the new developed model and asked to score their learning outcomes. The questionnaire of 14 students is shown below.

1-Critical Thinking Skill: Skill, was examined under the titles of design problem definition, data analysis, data synthesis, and idea development. More than half of the students stated that they developed critical thinking skills. 84.5% stated that they improved their design problem definition skills, at least two-thirds stated that they improved their synthesis and idea development skills. In Figure 18, it can be said that synthesis and idea development skills are less developed than the ability to define data analysis and design problems. However, less than one-third rated their idea development and data synthesis development skills as 2 or 3 out of 5.

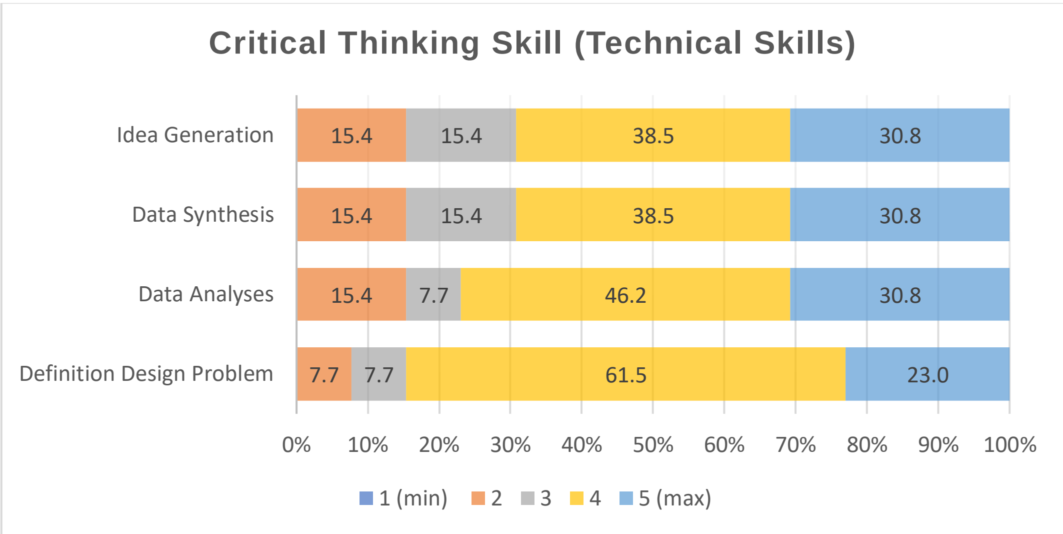

Figure 18. Student Questionnaire -1

2-Professional Skills: Skills was examined under the titles of conceptual DP and project management. As shown in Figure 19, 92.3% stated that they learned the conceptual DP through the newly developed model. More than two-thirds stated that they improved their project management skills. Some students had difficulty in keeping up with the schedule of stage contents and timelines (Table 3). It can be said that the project management score is underestimated.

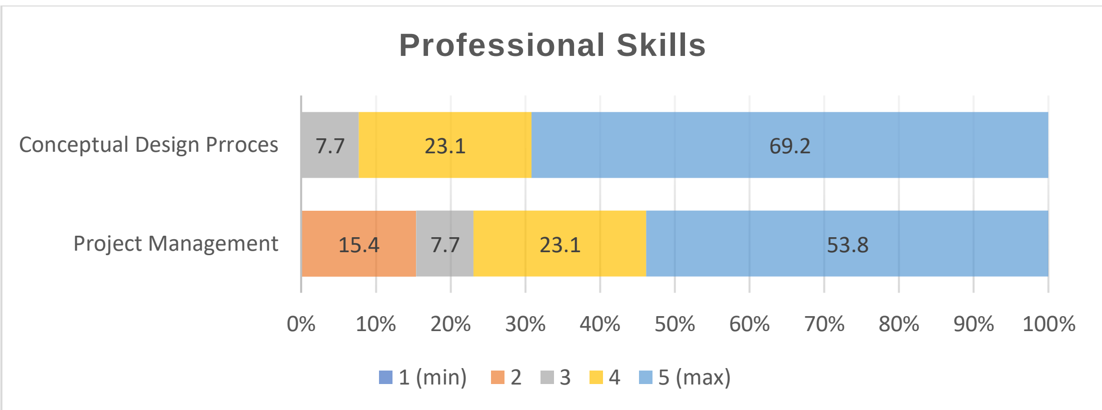

Figure 19. Student Questionnaire-2

3- The Effect of Systematic Research on Learning: It was investigated with 8 questions presented below. The acceptability of the sentences presented by the students was evaluated with the Likert scale. Results are presented in Figure 20.

- Q1: I learned to do research that will benefit my project.
- Q2: I have learned to analyze research data.
- Q3: I learned to obtain data from my research.
- Q4: I developed my project idea based on the data I obtained from research.
- Q5: I learned to synthesize the data I obtained.
- Q6: I understood the relationship between ideation and research.
- Q7: I understood the relationship between design process stages.

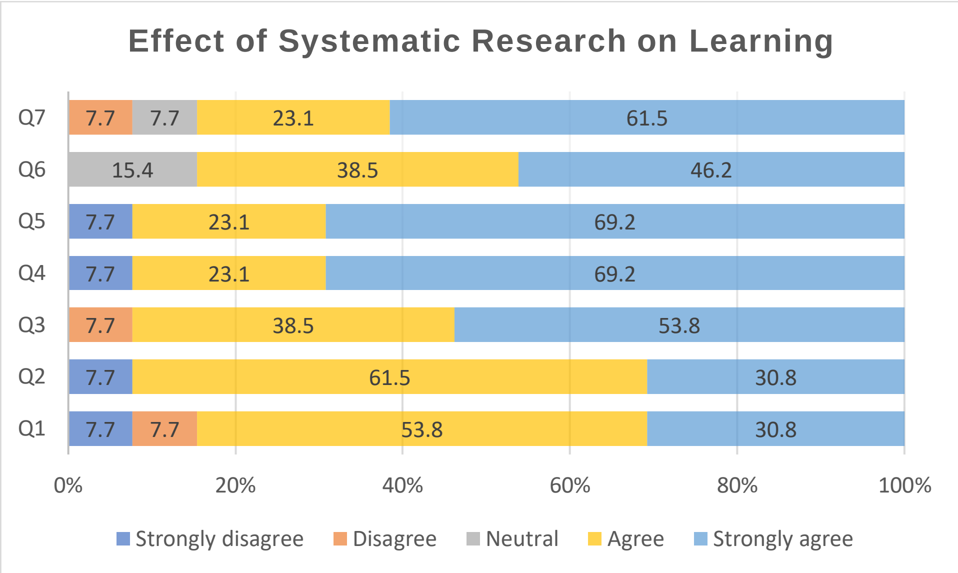

Figure 20. Student Questionnaire-3

Two-thirds using the new model comprehended the data they obtained through research. They stated that they understood the effect and importance of the data obtained as a result of the research on the development of the project. The students stated that they learned the relationships between the stages of the DP and have experienced the DP that had to progress cumulatively. 15.4% stated that they were undecided in the effect of the research on idea development.

4- Contribution of the Project to Personal Development: It has been researched with the next 2 questions (Figure 21). While 92.3% stated that their individual awareness of designing for disabled individuals has increased, they also have realized their professional responsibilities. 92.3% said that they obtained scientific data about disabled individuals through a research-based project as 4 and 5 out of 5.

- Q8: I have obtained scientific data on disabled individuals.
- Q9: I have increased awareness of design for disabled.

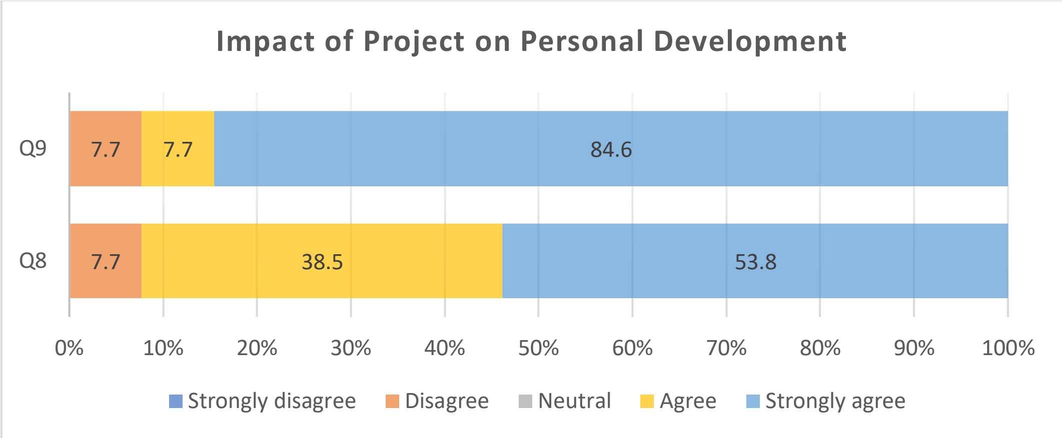

Figure 21. Student Questionnaire-4

5- The Comparison of the New Model with the Traditional Models: It was aimed with the following questions (Figure 22). It was evaluated as 4 and 5 out of 5 that the students benefit more from the research results through the new model. The relationship between the newly developed model and the stages of the conceptual DP that needs to progress cumulatively was comprehended by the students 76.9% more. Students made lower evaluations of the effect of the new model on creative idea development.

- Q10: I benefited more from my research while developing my project.
- Q11: I understood the relationship better between the stages in the process.
- Q12: I developed a more creative idea.

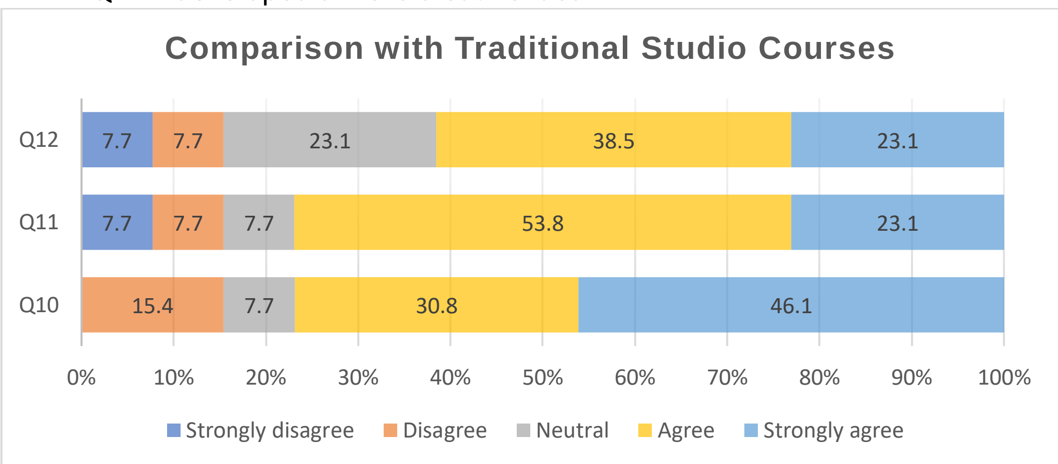

Figure 22. Student Questionnaire-5

Lecturer reviews of projects

The lecturers evaluated the process and project using the Likert scale. Project management, critical thinking and reporting quality are determined as process criteria, while project evaluation criteria are consistent cause-effect relationship, presentation quality, communication skills, innovation. After taking the average of the lecturers' evaluation results, the final results are shown in Figure 23.

As shown below, project management, critical thinking process criteria and consistent cause-effect relationship, presentation and communication skills were mostly rated as accomplished and exemplary.

However, creativity and report quality criteria were evaluated lower than other criteria. It is known that design students are generally insufficient in preparing written reports. More than half of the class was evaluated at developing and beginning levels in the report quality criteria. Innovation criteria evaluations are of equal weight in beginning, developing and accomplished degrees.

The evaluation of students' critical thinking skills including problem definition, analysis, and synthesis activities as accomplished and exemplary shows that students use research data effectively in their projects. Therefore, the criterion of cause-effect relationship was evaluated at an approximate level with the criterion of critical thinking skills.

In the visualization phase, the students presented ideas effectively. While 77% were rated developing and accomplished in visualizing the design idea, 7.7% were rated as exemplary.

69.3% were rated as developing and accomplished in their communication skills. This criterion evaluation can be explained by the fact that students mostly have to use verbal communication during the distance learning-teaching period.

According to the lecturers' observations, the projects are generally at an accomplished level. It can be said that the goal of developing critical thinking skills and learning the conceptual DP are mostly achieved with the new model. However, a small part of the class met the expected level in the innovation criteria.

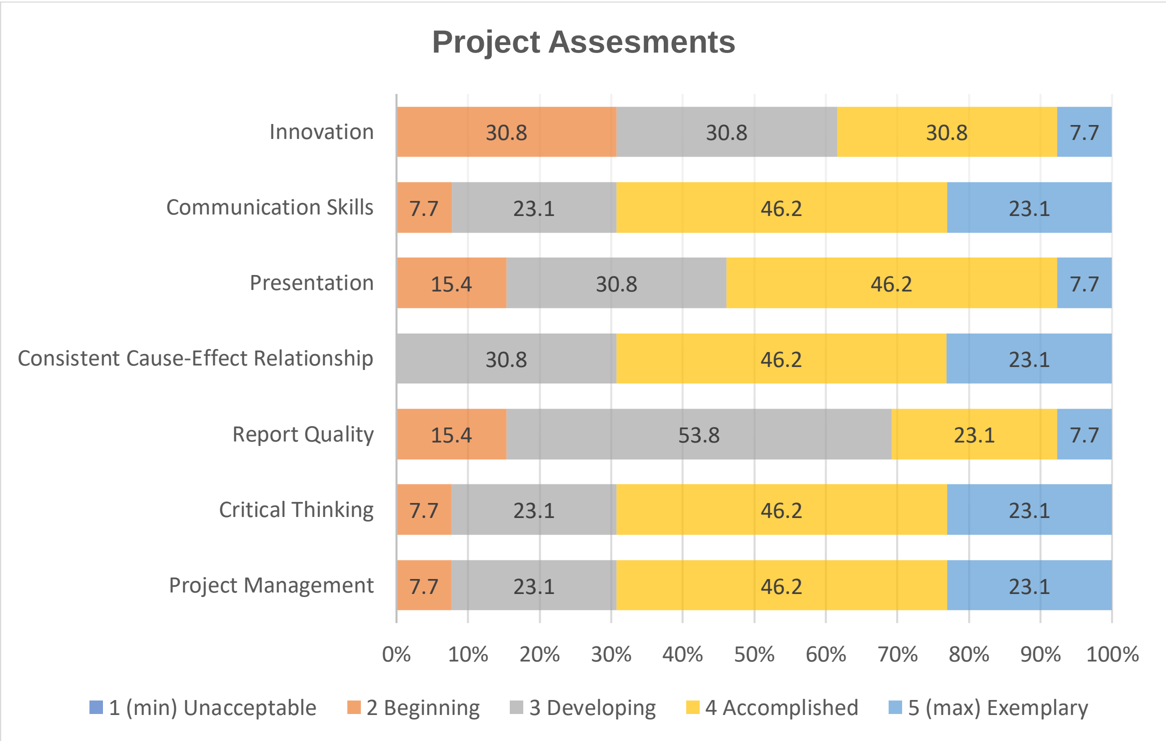

Figure 23. Evaluation of CD Projects

Discussion and Conclusion

In this study, a toolkit focused on IBL was developed to ensure that the conceptual DP defined as fuzzy front-end can be comprehended by students. This toolkit consists of 8 stages of conceptual DP tool and matrix as presented. The tool set has been developed with the approach that the DP can only be comprehended when it is structured systematically (Archer, 1965) and Wildt's (2009) inquiry-based active learning approach. The main purpose of the toolkit is to guide students to develop design solutions consistent with the design problem and develop critical thinking skills. The new tool developed encourages critical thinking about the aspects of the problem that need to be addressed to develop a good design idea, with guided questions in the process stages. The new teaching model was applied in the Design for Disabled Class at Gazi University during the Covid-19 pandemic in the 2019-2020 Distance Learning School year. The methodology of the project is designed to achieve the determined learning outcomes. Students have developed different innovative solutions for individuals in different disability groups. The new teaching model was evaluated by the students through a questionnaire. Student projects were evaluated by lecturers using a rubric.

Through the systematic and task-oriented new model, students are guided to create a consistent cause-effect relationship between the design problem and the design idea they developed. It has been ensured that the relationships that they need to establish between all stages of the conceptual DP, which must progress cumulatively, are comprehended. A significant portion of the students found that the new model improved their critical thinking skills. The students stated that the ambiguity of their research purpose in the previous project is a waste of motivation and time. The students experienced the effect of a conscious and systematic research, starting with a question, on creating knowledge, developing the design problem, its solution and idea through analysis and synthesis throughout the DP. The students acquired this experience through iterative stages.

When research is mentioned, students who focus on non-scientific written and visual data through internet resources have realized the effect of scientific research on developing design ideas with this project. Students stated that with the design project for the disabled, they used written and visual resources more consciously and effectively than ever before, and their data literacy skills improved.

In the new learning model developed, they stated that the phase in which the students had the least difficulty was the visualization phase. It was stated that the most challenging phase was the creative phase and the analytical phase, respectively. Students have not carried out a research-oriented project in their past education process, and they mostly conducted research on the superficial and late design phase such as sample analysis, user comments, user needs, product technical analysis, material selection.

Students have stated that their professional responsibility and awareness in the field of social design increased. While the projects developed by students for children and adults with disabilities are in the fields of music, sports, professional life, games, social areas and education, the students addressed games, social areas and education more than others. However, the lecturers stated that the courses with social design content are in the lesser number of university curricula.

According to the results of the evaluation made by the lecturers, the success of the students in the process was found satisfactory. While the projects are mostly found successful in the cause-effect relationship criteria, it is not the case in the innovation criteria.

It was stated that in this project, the design students were less successful in the fields of research or presentation report creation, written text creation, written communication when compared to visual communication areas. This can be explained by the fact that design departments include more visual presentation techniques in their curriculum. However, written text literacy of students also needs to be improved.

Combining the Kolb learning model in which design students are positioned in active learning and the IBL model, Width (2009) states that active learning takes place with research.

The evaluation criteria made by the lecturers were determined according to their learning outcomes. According to the results, project management, critical thinking and consistent cause-effect relationship, presentation and communication skills were mostly rated as good and extraordinary. However, a small part of the class met the expected level in the innovation criteria. It can be said that the goal of developing critical thinking skills and learning the conceptual DP are mostly achieved with the new model.

The similarity rates of the data obtained through the scientific literature research conducted by the students are quite low. Most students focus on similar problems and develop similar solutions, as they do similar research in their projects where they do not apply any model. Even if similar problems are handled in the above projects where the new conceptual design model is used, there is no similarity between the solutions developed. Although the students with Project 1 and Project 2 both developed projects for the visually impaired, they were able to develop quite different, impressive, and innovative processes and techniques in their projects by using the new model. The student who has Project 3 has successfully synthesized the existing scientific knowledge with the matrix he has completed based on scientific research and presented a new approach that keeps up with the digital age. Although the owner of Project 4 did not develop an innovative solution, he developed a quality solution in terms of ergonomics and organization by successfully synthesizing the scientific data he obtained in the field of ergonomics and establishing cause-effect relationships well.

More comprehensive results can be obtained by repeating the study with a larger sample group as this researched was done with a limited number of students. The overall results of the project showed that the new model has improved the design students' competencies and learning outcomes. Although the research focused on design for the disabled, the developed process model can be adapted to different design problems.

Students could not develop their projects as prototypes and discuss their results with users because the research focus was conceptual DP defined as fuzzy front-end, in other words, early design process. By completing the entire design process (early and late design process), different findings and results can be obtained with a repeated study.

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An Experimental Framework for Designing a Parametric Design Course

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Abstract

Architectural forms, architectural knowledge, design process, and design thinking are all changing with the use of computer-aided design programmes, and even traditional university architecture departments now wish to teach these programmes. However, it can be difficult to implement courses on such computer programmes because these departments have traditionally structured curricula. We developed a framework that can inform the design of a parametric design course which considers the university profile, the course profile, and the student profile. This framework evaluates the departments in three categories: 'open to new design approaches', 'supportive of CAD' and 'reject new design approaches'. A parametric design course in relation to the proposed framework was designed and implemented as a case study. The process and the results were discussed.

Keywords

Parametric Design, Design Education, Design Process, Architecture Curriculum.

Introduction

Change in architectural forms, architectural knowledge, design processes, and design thinking has occurred due to the use of various computer-aided design (CAD) tools in the architectural world. These changes are also reflected in architectural education. Especially in graduate programmes, expansions are being made and new methods are being tested. In particular, teaching methodologies for parametric design are being researched all over the world since there is a growing demand for computer programming logic in the field. At the undergraduate level, such knowledge is equally needed; however, it is still a challenge for both students and teachers to incorporate it into undergrad programmes, which are still rather more structured and traditional. For this reason, a framework is needed for designing parametric design courses. The framework is proposed to support the challenge of incorporating parametric design tools on programmes of study. The framework supports course instructor to build a parametric design teaching methodology by articulating the conditions or characteristics of individual programmes.

Paradigm Shift

In order to create a framework that can inform the design of a parametric design course, it is necessary to first examine the change caused by the effect of computer aided design tools on the architecture world. We can classify these changes as form-based change, change in architectural knowledge, change in design process, and change in design thinking. It is important to consider these changes which are reflected to a certain extent in parametric design education, depending on the scope of the course.

Complex geometries have begun to be created with the rapid development of computer-aided design tools. With today's tools, it is possible to not only create but also revise and refine these complex forms without the necessity of remodelling many sub-parts (Burry, 1999; Woodburry, 2010; Jabi, 2013). With developing technologies, such as 3D printers and robots, complex and unique forms can now be produced. The interest of architects naturally shifts to these complex forms. This, in turn, pushes research toward the development of new construction techniques and the search for new materials with which architects can extend these complex forms and satisfy their aesthetic understanding and vision (Kolarevic, 2003). The increased use of various design tools has also changed architecture as a discipline. New ideas also begin to emerge as novel conceptual structures arise in the field (Oxman, 2008). This suggests that architectural knowledge can change periodically.

The design process is becoming more holistic with the use of emerging technologies. New technologies allow designers to make more than one design decision in the early stages of design (e.g. using optimisation tools). For example, decisions about fabrication and the use of materials are now made at the beginning of the design process (Menges, 2008; Hensel and Menges, 2008; Hensel et al., 2011). This situation in turn increases interdisciplinary interaction and makes collaborative work more important, as the range of the parameters considered can increase and thus different fields may be included.

Unlike CAD tools, parametric design tools allow for the iterative process which is essential in sketching and designing. The parametric design tools do allow this type of process, showing a similarity between the pre-computer cognitive model of design thinking (Oxman, 2017). In the era of design with paper and pencil, the designer used conceptualization, modification and refinement (Cross, 1982; Cross, 2011), in addition to observation and visual documentation (Schon, 1983, Schon, 1987, Schon, 1988). They always employed iterative processes in the sketching process (Schon and Wiggins, 1992; Goel, 1995; Do et al., 2001; Suwa and Tversky, 2002, Goldschmidt and Smolkov, 2006), which is essential to developing design ideas, as design thinking is not a linear but a non-linear or 'ill-structured' process (Bhooshan, 2017). In addition, due to the re-editing feature of parametric design tools, surprises occur in the design process just as they do in manual design. Schon (1983) discusses the concept of 'surprise' in his creative design theory, which takes the designer away from the routine process and thus gives originality to the design project (Dorst and Cross, 2001). Early CAD tools do not allow such iterative processes, because they do not have re-editing features. A case study comparing CAD tools with manual sketching, conducted by Veisz et al. (2012), found that conceptual design requires a more human-centred process. This is probably because it is easy to make iterative movements with manual sketching.

Parametric Design Teaching Methodologies

The change of paradigms in the architectural world has affected architectural education, as noted above. Due to the emergence of computer-aided design tools and fabrication systems, the need to integrate digital design into architectural design education is becoming increasingly great. Today, graduate as well as undergraduate architecture programmes in many architectural schools are beginning to encourage an intensive use of computer-aided design tools.

Various parametric design teaching methodologies have been tried by researchers. For example, Headley (2013) and Lordanova et. al. (2009) conducted studies that integrated parametric design systems into the design studio in an undergraduate architecture programme. The study by Lima et. al (2020) included the use of shape grammars and parametric tools in the design studio. Schnabel (2013) implemented an integrated design studio method titled as a parametric design studio course, because he thought that the integration of digital media into design studio curricula prevented deep exploration in design. Nakapan and Onsuwan (2018) proposed a parametric design studio within the scope of a vertical studio. Agirbas (2018) used metaphors as the basis for a parametric design teaching methodology in an elective course.

For undergraduate design education, Aish and Hanna (2017) considered that different parametric design tools might have different effects on the parametric design thinking, compared three different parametric design tools (GenerativeComponents, Grasshopper and Dynamo) in terms of cognitive dimensions. This assessment can inform programmes development from a new user's perspective as well as programme choice by undergraduates based on which one they feel closest to in terms of both cognition (and thus in principle can use most productively) and the nature of the task at hand.

It should also be noted that, in general, many studies have explored the relationship between computer tools and design education. Many researchers have searched for cognitive effects of the computational approach on the design process in the educational context in order to model it within design theory (Oxman, 1999; Cuff, 2001; Knight and Stiny, 2001; Oxman, 2008; Oxman, 2017). Studies have also been carried out on students' attitude towards the use of computers in the design process (Hanna and Barber, 2001; Basa and Senyapili, 2005; Pektas and Erkip, 2006).

As Oxman (2008) said, 'Digital design theory has transformed the concept of form into the concept of formation'. Digital formation models are becoming conceptualization tools. The formation process becomes more interesting than the idea, and ambiguous effects can occur in this process (Zaero-Polo, 2001). Parametric design tools reveal topological variations in concepts, and different form configurations are associated with different parameter values. In addition, as mentioned above, in the process of using parametric design tools, the cognitive model of design thinking with its iterative process, advanced through conceptualization, modification, and refinement (Cross, 1982; Cross, 2011) or through observation and visual documentation (Schon, 1983; Schon, 1987, Schon, 1988), emerges as similar to the paper-based design process and different from CAD.

Most new experimental methods are usually implemented in the design studio. However, in many architectural schools around the world, design studios employ more traditional methods in architectural undergraduate education. The reasons could include unwillingness to change, inadequate knowledge of students by teachers for more innovative methods to be effectively applied, or the fact that people completing undergraduate programmes are often designated architects, with signoff authority on projects, so that directors of architecture programmes prefer to make sure more technical information is instilled, for safety and for the graduates' basic professional effectiveness. However, in some architectural undergraduate programmes, despite the traditional orientation, courses in computer-aided design tools have been added at students' demand, and better practice around the teaching of those tools is thus already needed.

As exemplified above, many parametric design teaching methods have been tried. However, to date, no studies suggesting a framework that can inform the design of a parametric design course exist in the literature. Such a proposal could be a guide for applying the parametric design teaching methodology, especially for traditional architecture departments.

A Framework for Designing a Parametric Design Course

In parametric design teaching, characteristics such as university profile, student profile, and course type should be considered when preparing a teaching methodology and/or design process scheme. In other words, parametric design teaching methodologies will vary according to these conditions. In this section, a framework that can inform the design of a parametric design course for an undergraduate architecture department is suggested (see Figure 1).

Considering the university profile, student profile, and course type helps the instructor create more accurate teaching methodology. Because there can be departments, student profiles or course profiles at many different levels.

Characteristics

Department profile. First of all, we should consider the curriculum of the undergraduate architecture department at the university where the programme will be implemented. The answers to the following questions should be sought in the curriculum. A key to the answers of these questions is provided in Table 1.

Are there courses that teach computer-aided design programmes? If so, the architecture department is to some degree open to helping its students learn computer-aided design programmes. Most architectural departments now seem to be open to computer-aided design programmes for reasons of accreditation and student demand.

If so, are these courses compulsory or elective? If it is a compulsory course, the architecture department is likely more supportive of learning computer-aided design programmes.

What computer-aided design programmes are taught in these compulsory or elective courses? In particular, are general programmes (such as AutoCAD) taught, or are the programmes (e.g. programmes that have script editors) that are taught more recent or lesser known ones? If the latter, the department is seemingly more open to new technology and new design approaches; if the former, it may be more traditional.

How many hours per week are these lessons? Especially where the teaching of computer-aided design programmes is not accompanied by a design studio course, more weekly hours and containing practices may show the importance the department ascribes to training in computer-aided design programmes.

Is there a difference between weekly hours of classes that teach different computer-aided design programmes? In particular, do the courses that contain content in regard to teaching programmes with script editors have fewer weekly hours than other CAD courses? For example, if both a CAD programme (like AutoCAD) and a parametric design programme are taught in the architecture department, but the CAD programme is taught for 4 hours and the parametric design programme for 2, the department of architecture seems to have given more importance to the teaching of the CAD program.

Are computer-aided design tools taught within the scope of the design studio? There is no clear-cut opinion as to whether computer-aided design tools are better taught within the design studio. However, the design studio course's hours and credits are usually higher than other courses. Considering this, integrating the tools into the design studio indicates that the department may find it important to teach with these tools. It is especially important to encourage the use of tools simultaneously during a specific project. For example, if this occurs in a design studio environment, there will be enough time for the student to learn and apply these tools, while simultaneously generating their own script for the direction of the project. In contrast, if learning is conducted in a separate lesson outside of a design studio, the process will be more difficult.

Does the design studio tutor comprehend the logic of computer-aided design tools? Can the design studio tutor use computer-aided design tools, or do they have an assistant who can? Evidently, such a tutor will better orient the design process in relation to the logic of the tools and ideally is experienced using them first-hand.

In the design studio, are alternatives to traditional methods tried? Testing alternative methods shows that the department is aware that computer-aided design tools change paradigms in the architectural world and intends to contribute to the understanding of effective practice in architectural education.

Table 1. Key to finding answers to the questions

Question	**Where to find the answer**
Are there courses that teach computer-aided design programmes?	Course list
If so, are these courses compulsory or elective?	Course list
What computer-aided design programmes are taught in these compulsory or elective courses? In particular, are general programmes (such as AutoCAD) taught, or are the programmes (e.g. programmes that have script editors) that are taught more recent or lesser known ones?	Course list Syllabus
How many hours per week are these lessons?	Course list
Is there a difference between weekly hours of classes that teach different computer-aided design programmes? In particular, do the courses that contain content in regard to teaching programmes with script editors have fewer weekly hours than other CAD courses?	Course list Syllabus
Are computer-aided design tools taught within the scope of the design studio?	Syllabus
Does the design studio tutor comprehend the logic of computer-aided design tools? Can the design studio tutor use computer-aided design tools, or do they have an assistant who can?	Background of the lecturers
In the design studio, are alternatives to traditional methods tried?	Syllabus

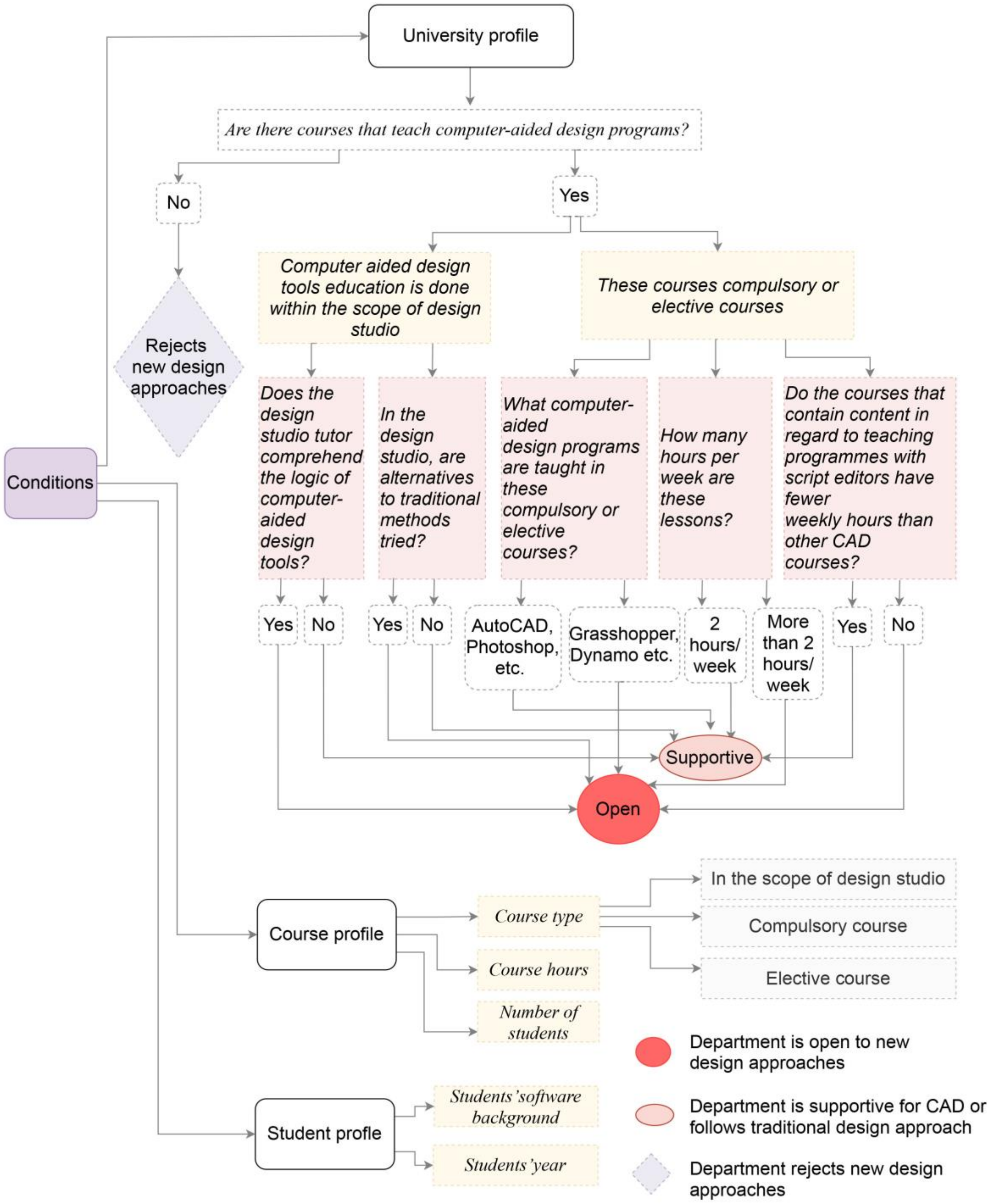

Figure 1. The proposed framework that will help programme designers

Course profile. It is necessary to do applied work for parametric design education in undergraduate architecture education. In carrying out this applied work, the following factors are important: course type, course hours, and number of students.

Course type: Whether parametric design tools are to be taught in a compulsory course, an elective course, or the design studio in architectural undergraduate education is an important criterion in determining the methodology to be followed. If parametric design tools are taught in the design studio, many alternative methods can be tried, whereas if it is taught in a compulsory course or elective course, it is difficult to make the application work because opportunities for application are lacking, though sometimes teaching can be split between these contexts, allowing applied work. In addition, students may put more effort into their compulsory courses in comparison to their elective ones. This is because students are required to repeat compulsory courses upon failure, which may lead to the loss of a semester.

Course hours: If the hours of a compulsory course or elective course dedicated to parametric design tools are sufficient, applied work can be done independent from the architectural design studio course. If course hours are limited, in contrast, this will be difficult. This is because, in this limited time period, the student is expected to develop a new project from scratch in order to perform the applied work.

Number of students: Another criterion is how many students are in the course, because it is difficult to do applied work in a class with many students. However, to combat this issue, group studies can be considered.

Student profile. In determining the methodology to be followed, it is useful to know what computer-aided design tools students can use and how many years students have studied architecture. Thus, the scope and method of teaching to be given can be determined more easily.

Students' software background: If students have prior knowledge of programming (e.g. the programmes with script editors that have re-editing features), the methodology to be followed will be different.

Students' year: The students' academic year in architectural education (e.g., first year, third year) can partially act as a proxy for their level of design knowledge and thus help determine the level of design work students will be asked to do.

Based on the answers to these questions, a computer-aided design tutor will comprehend the general orientation of the department toward computer-aided design. The template recognises three types of viewpoints in this regard: the department is open to new design approaches, it is supportive of CAD while following traditional design approaches, and it rejects new design approaches (Figure 1). New experimental methods can be applied for the departments in the 'Open' category. In the 'Supportive' category, based on the traditional teaching approaches infrastructure, new digital media can be included in the process and various studies can be performed.

Case study

To begin, the architecture department where the case study will be conducted has been analyzed according to Figure 1 and its characteristics determined. This study has been conducted in the department of architecture at Fatih Sultan Mehmet Vakif University. As discussed in detail below, the department falls into the 'supportive' category. A method for parametric design teaching was determined based upon these characteristics.

Student productions are included in this study. However, it is not discussed whether the parametric design teaching method applied here is a suitable method in parametric design education. To validate this, separate tests are needed.

Characteristics

When the university's curriculum, in which parametric design teaching is included, is examined, it is seen that some courses in computer-aided design education are compulsory and some are elective: Photoshop, AutoCAD and Revit are taught in the former, and 3Ds Max, ArchiCAD, Maya, Rhino and Grasshopper in the latter. The compulsory Revit course is 4 hours weekly, while the elective courses are 2 hours.

One of the answers to the question in the proposed framework (Question: Is there a difference between weekly hours of classes that teach different computer-aided design programs? In particular, do the courses that contain content in regard to teaching programs with script editors have fewer weekly hours than other CAD courses?) has been released as supportive. Therefore, this department was evaluated as supportive category.

Furthermore, it seems that in this department, computer-aided design education is given outside the architectural design studio, which itself is completely traditionally handled. Students' computational knowledge, learned in compulsory or elective courses in computer-aided design, is introduced into the studio only through their own initiative. However, studio instructors and their assistants support the use of computer-aided design tools. In this department, although the laser cutter is widely used in the studio, use of the 3D printer is very rare.

The department offers an elective course called 'Introduction to Parametric Design' on the programmes Rhino and Grasshopper. It is 2 hours a week. Consequently, the students have limited time to complete the work. The semester consists of 14 weeks. The course can be taken by students at any level. The section considered here had 15 students.

The students may have experience with 3D modelling programmes but do not have experience using parametric design tools based on a visual programming language. The method used to help the students understand the design-thinking logic of Grasshopper is explained below.

Methodology

After reviewing the characteristics, the methodology of the case study has been determined. Considering the university profile, course profile, and student profile, a methodology was determined as detailed below (Figure 2, Figure 3).

Since the students, who take the course covering parametric design education, do not have scripting knowledge, VPL (visual programming language) is first taught as a lecture. 3D modelling in Rhino and visual programming language basics (Grasshopper) are taught. Because the course has a limited time (two hours elective course), ready-made scripts are used. Later, in the traditional design studio context, the basic aim is to teach students the four changes (form-based change, change in architectural knowledge, change in design process, and change in design thinking) discussed in the paradigm shift section (Figure 2).

Students have general knowledge about traditional design methods since they learn these methods in the architectural design studio. It was thought best to find ways to utilise this basic knowledge of the students. Thus, a fully alternative approach to learning was avoided, and students used parametric design tools in close adherence to the logic of the design principles taught in the studio, focused on form creation (Figure 2). Conceptualization, modification and refinement, which are widely used in traditional design studio training, have been included in the process by playing with the script. At the same time, students have experienced the digital sketching process by observing changes on the basis of form through script configurations. With the form formation model, the goal is that students gain knowledge on form-based change and on change in architectural knowledge. In this strategy, students are required to eliminate the issues such as performative, structural, or sustainability issues in the limited period of time of the course. Therefore, the students focused on form formation only. This allowed the students to modify the ready-made script, that is, to make changes by playing with various parameters in the script at the form formation basis.

Students learn primarily the use of ready-made scripts according to the purpose, to understand the flow of the script in general, change the slider parameters according to the design, and if necessary, include other components to the script. With this learning style, the student can create and modify more comprehensive or complex forms in a shorter time. Therefore, the student can understand what parametric design tools will be useful in a real sense. In addition, while creating forms, the student can understand the relationship between the variations of the object and the script in different configurations and can refine the form with the slider parameters by observing it and therefore, can experience a design process related to the form. At this stage, the goal is for students try to establish a relationship between VPL and sketching and to gain knowledge about changes in design thinking.

Throughout the learning period, the student must be able to obtain information about what parametric design is and what will benefit from it. Otherwise, students at the undergraduate level may cease to continue learning the program, as they find they cannot test geometrical productions at a certain level of complexity with the program; especially in the early years of undergraduate education, learning the production of a few basic geometrical objects in the visual programming language is not enough to really see what parametric design tools can do. Therefore, design work that is performed with parametric design tools needs to reach a certain level of complexity in order for its value to become apparent. This factor should be included in the teaching methodology. In order to be able to see clearly what the parametric design tools can do, students need to create a design product, as noted; therefore, although time was limited, applied work was decided on.

Nowadays, since decisions about the choice of fabrication method and choice of materials are taken from the beginning of the design process, it was thought to be necessary in our course that digital fabrication should also be included in the design process. That is, at a certain stage of the formation process, students were directed to think about the form they had created in relation to the fabrication process. In this way, the aim was to provide students with information about change in the design process.

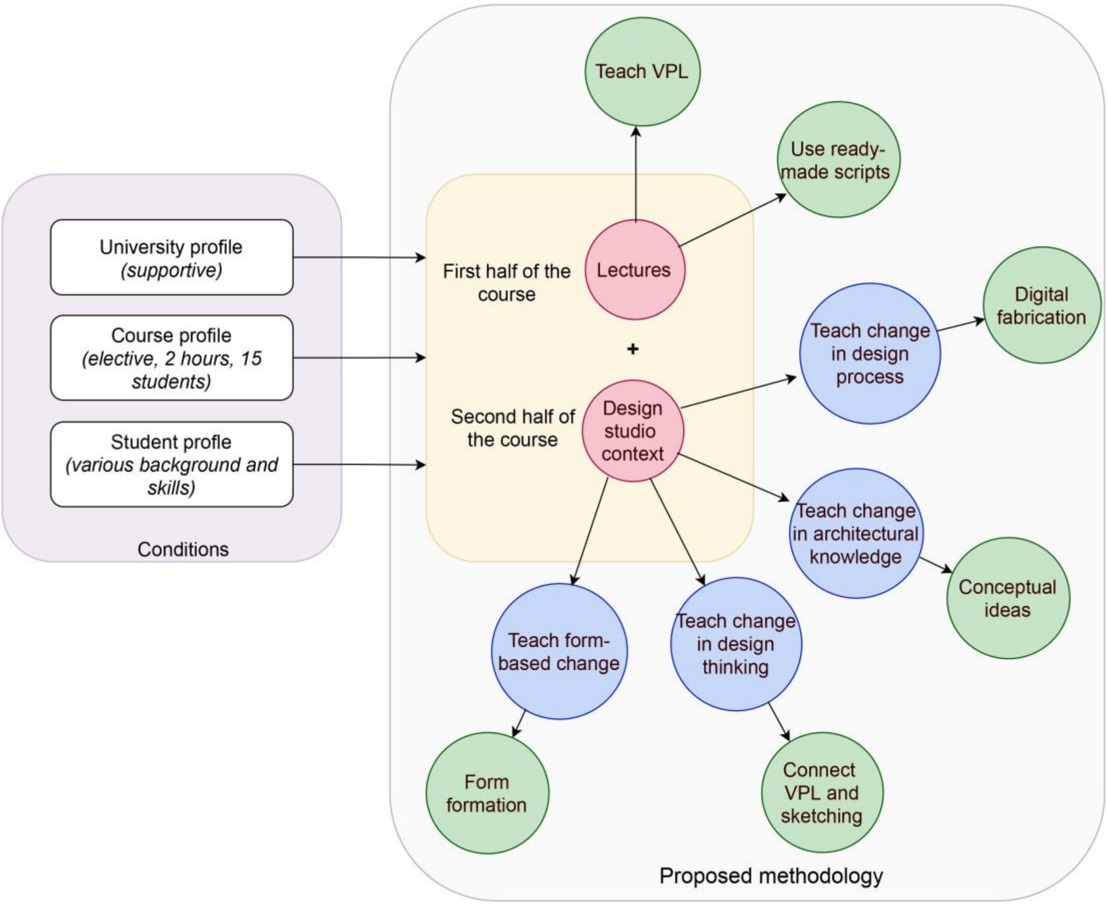

Figure 2. Proposed methodology for parametric design teaching in an architecture department in the 'supportive' category.

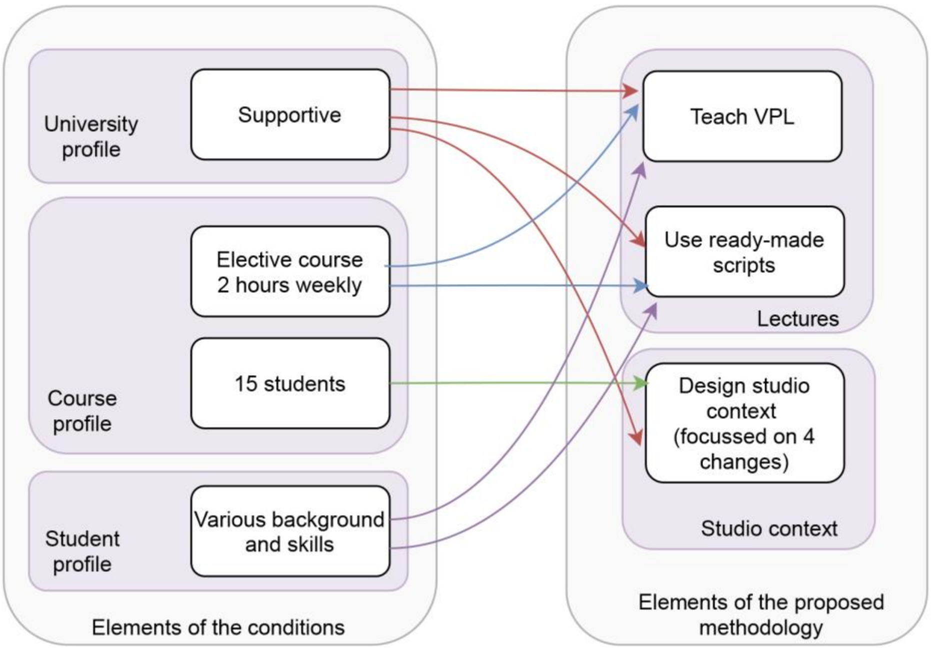

Figure 3. Proposed teaching methodology according to the conditions

Course Outcomes

The students came up with ideas from very large to small scale in their designs; for example, while some of them were designing skyscrapers (Figure 4, Figure 5), others preferred lamp design (Figure 6). Apart from this, there were no significant differences in the design quality of students' designs.

Each student first parametrically modified the given script (i.e. the ready-made Grasshopper code) by changing the sliders, which covered parameters such as width, length, and curvilinearity.

With the Morph component in the script, each student tested the placement of different units on the surfaces. Work related to the formation of different textures and bringing the different units together took place widely across the design process. For example, design experiments using different units can be seen in Figure 4 and Figure 5 (respectively).

Some students developed designs by combining the forms that they could produce using the script. For example, in Figure 7, the form was generated three times with the script, and the design was developed considering the three forms together, although they are independent from each other in the context of the script.

Although some students were not asked to set a relationship with the built environment, it was observed that they attempted to relate their forms to the built environment that they either chose or designed by themselves. For example, in Figure 8, the student preferred to place his form against an Egyptian pyramids visual, and established a metaphorical relationship in doing this. In Figure 9, the student preferred to model his bridge design to match its surroundings. Again, in Figure 5, the student preferred to contextualise his skyscraper design by placing other skyscrapers around it. It should be noted that, in their previous traditional architectural design studio course studies, the students had tried to relate their designs to the built environment.

It has been aimed to teach VPL in the lecture part of the teaching methodology. As observed in the form creation process, the students were able to play with the script and modify the script in a certain extent. When we consider the design process and evaluate the final products, it is seen that this methodology enabled students to understand the capacity of parametric design tools in a limited period of time.

In the design studio section of the course, we observed that students understood form-based change, change in architectural knowledge, change in design process, and change in design thinking to a certain extent. Students engaged in visual reasoning and often revised the parametric form. In this way, they were able to gain understanding of design thinking change in contemporary architecture. To better connect the changes in form-based knowledge to developments in the contemporary architectural world, the students focused on complex form production. Thus, the students were made more knowledgeable about changes in the basis of real architectural knowledge. Digital fabrication and material issues were included with instruction on the formation process, to help students understand changes in the design process.

In the experimental methodology followed in this study, students were meant to be able to apply their already acquired knowledge. At the end of the study, it was seen that students did employ the traditional design studio techniques that they had learned before. For example, they followed an iterative form revision process, usually applying this technique at the beginning of the paper-based design process using the forms that they created with parametric design tools.

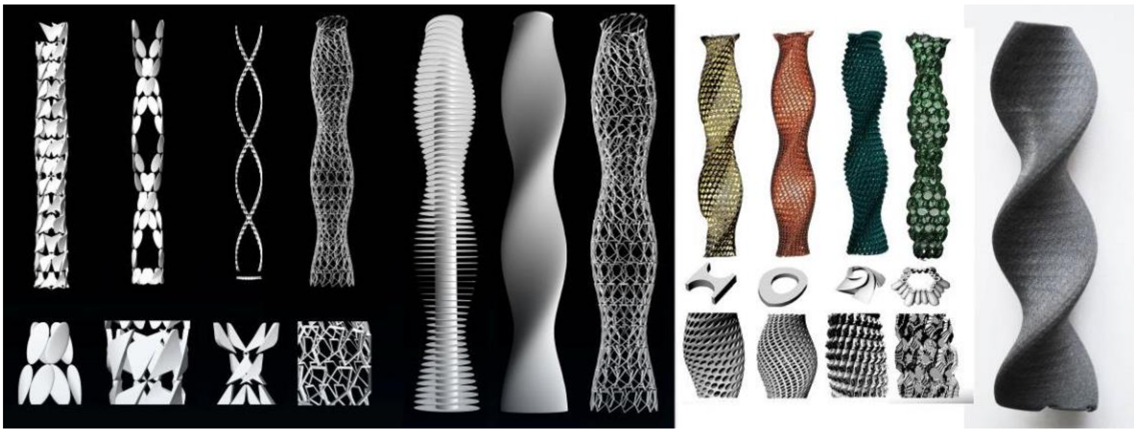

Figure 4. Student work (a skyscraper design study and its 3D print).

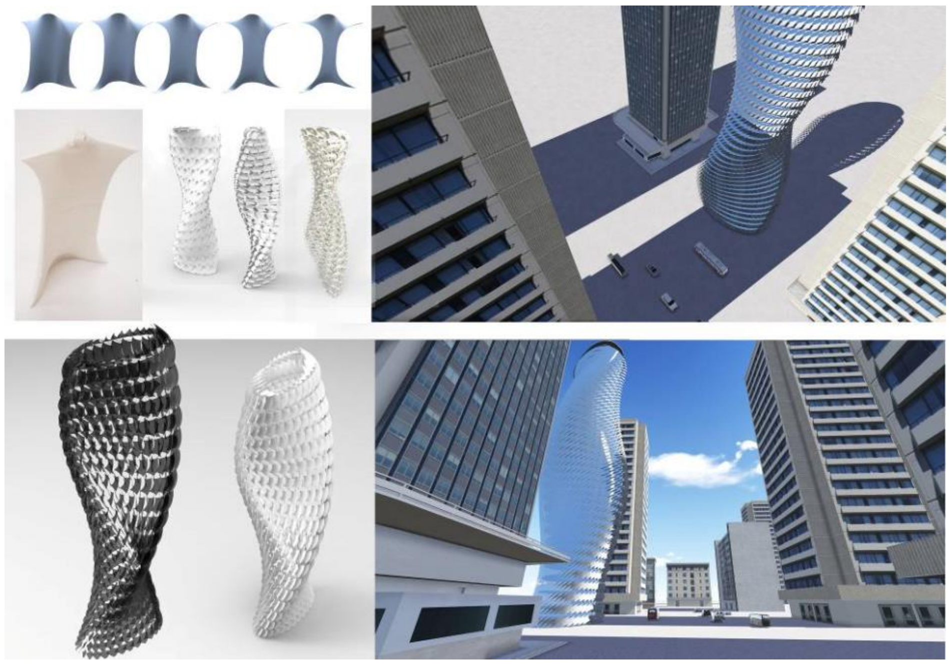

Figure 5. Student work (a skyscraper design study and its 3D print).

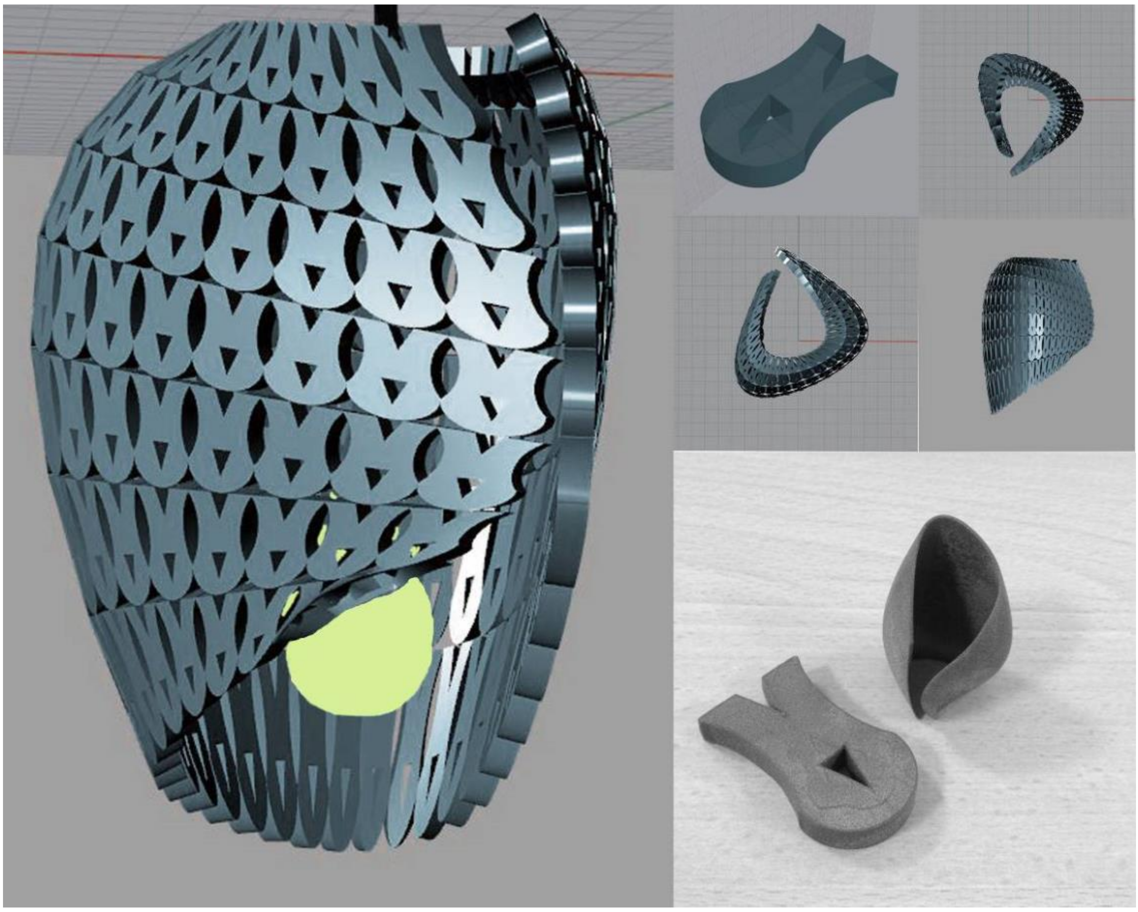

Figure 6. Student work (a lamp design study and its 3D print).

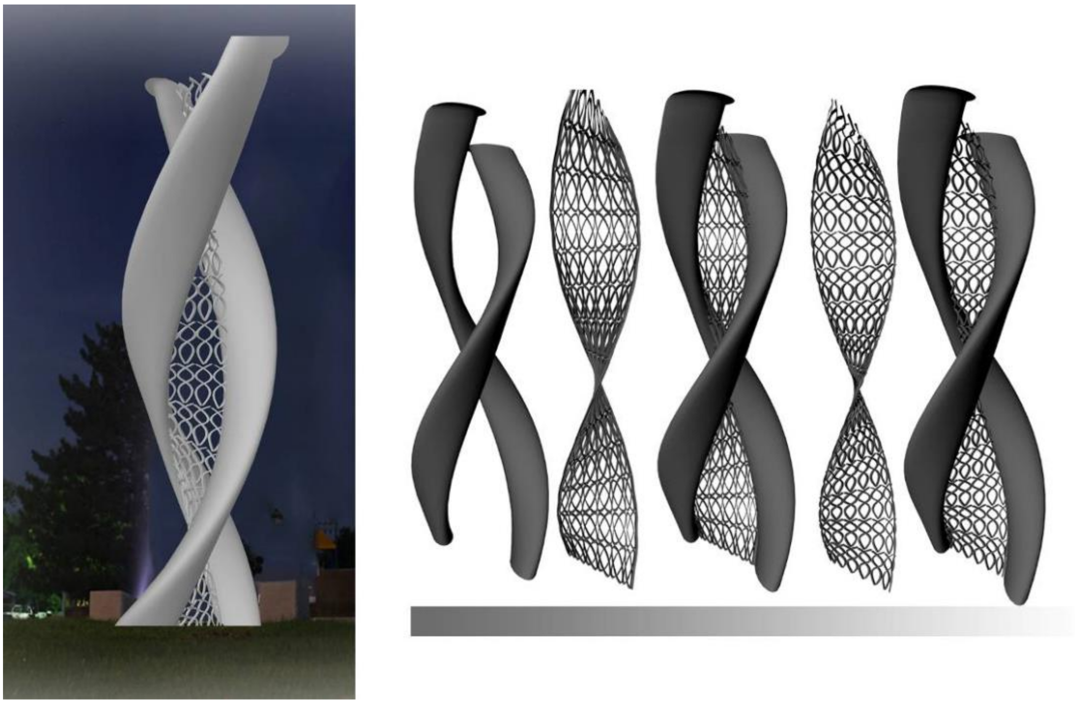

Figure 7. Student work (a memorial design study).

Figure 8. Student work (a science centre design study and its 3D print).

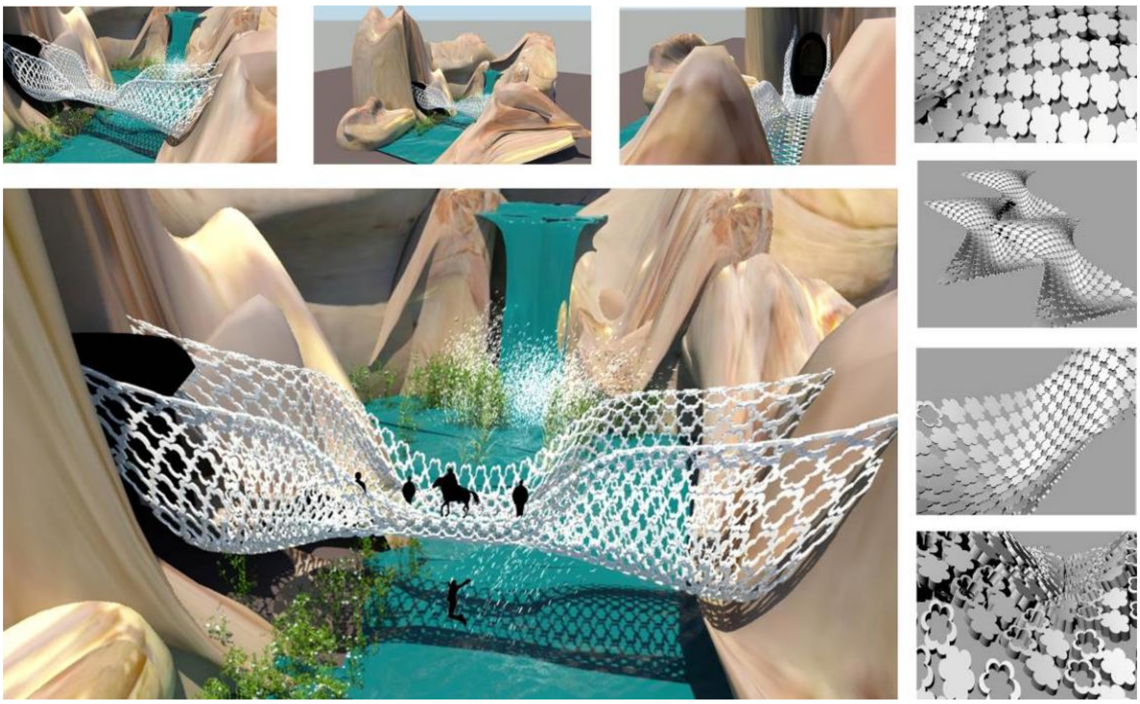

Figure 9. Student work (a bridge design study).

Conclusion

Digital design tools are constantly developing and becoming more complex. Therefore, it is necessary to educate the new generation of architects to use these tools. However, there are many different types of architecture departments. Before developing a parametric design teaching methodology, the characteristics of the different types of departments must be identified and the appropriate solutions determined. In this study, we developed a framework that can inform the design of a parametric design course, which considers the university profile, course profile, and student profile.

Within the scope of this study, it is suggested that the university profile, course profile and student profile should be considered when developing a framework for designing a parametric design. However, this method can be extended by adding other parameters.

The type of course in which parametric design education will be given is important in determining the instructional methodology, as parametric design education integrated into design studios and parametric design education given within compulsory or elective courses, will be very different. The parametric design instructor’s understanding of and attention to the student profile, in particular their technical knowledge and their cognitive model of the design process, will also influence teaching methodology decisions. Once these conditions are known, decisions can be made about which method will be applied to parametric design teaching. For all these reasons, parametric design education methodology may vary greatly among schools.

A case study was also conducted in this study. Before starting the experimental work in this study, the conditions of the site undergraduate architecture department (university profile, course profile, student profile), where the teaching of parametric design tools was delivered, were examined. As a result, it was seen that the architecture department was open to the use of computer-aided design tools but was teaching architecture using traditional methods. According to our proposed framework, this department fell under the category of ‘supportive’. Under these conditions, for teaching of parametric design programmes, a methodology was developed and applied in an elective course, in a limited timeframe. The evaluation of the success of the method discussed in the case study requires further and independent study.

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A-Level Food: The gap that remains: A research project on the impact of removing post 16 A-Level examinations for Home Economics and Food Technology in schools in England in 2016

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Abstract
This research project examines the impact of removing post 16 A-level examinations for Home Economics and Food Technology in schools in England from 2016. This research explores teachers' experiences from 2016-2020, specifically their views on the progression pathway for those students who wish to pursue further study and employment opportunities in the food sector and other relevant occupations. Schools offer non-A-level courses less frequently as there is uncertainty around course equivalence, and this has resulted in an overall reduction in the numbers studying post 16 food courses. Level 3 qualifications are now focused solely on the hospitality and catering sector with only one applied general qualification. Opportunities for broader areas of study that encompass food science, nutrition and dietetics and food technology have been removed. This has meant that now fewer students access broader career pathways and interests crucially at a time when the UK requires vast numbers of highly skilled postgraduate recruits for the food sector. Teachers made a strong case for why a new A-level course should be developed.

Key Words
A Level, Food Technology, Home Economics, Vocational Qualifications, Applied Qualifications, Qualifications Reform, post 16 progression

Introduction
This research report examines the impact of removing post 16 Advanced-level examinations for Home Economics and Food Technology in schools in England from 2016. The research seeks to explore teachers' experiences since this policy was implemented, specifically their views on the progression pathway for those students who wish to pursue further study and employment opportunities in the food sector and other relevant occupations.

Background
In 2016, as part of wider qualifications reform, the Department for Education decided that A-levels in Food Technology and Home Economics would cease in England. Amongst the reasons given were that there are several high-quality vocational qualifications available and there are applied general qualifications that have a focus on food nutrition and food science, which have been endorsed by universities. (Department for Education, 2016). This was based on an announcement of a consultation in July 2015, which stated that AS and A level food technology would not be developed as a separate qualification, as it has been part of the Design &

Technology suite and 'food' did not fit comfortably within design and technology suite of qualifications. Concerns have been raised about the negative consequences of this policy decision on the academic status and position of food in the curriculum. (Owen-Jackson & Rutland, 2017; Tull, 2018; Rutland, 2020; Wood-Griffiths & Lawson, 2020).

In February 2020, the British Nutrition Foundation (BNF) with the Food Teachers Centre concluded a quantitative study of 900 secondary schools in England. This author was the co-researcher during the survey which set out to ascertain whether there had been any impact on schools and students due to the removal of A-level. The results (British Nutrition Foundation & Food Teachers Centre, 2020) highlighted many areas of concern such as a reduction in teaching, funding, and status for the subject, but did not elicit the in-depth information needed to understand the issues in detail, as qualitative methods are better suited for this. (Strauss & Corbin, 1990)

As a separate inquiry, for the purpose of pursuing an M Ed, through a preliminary analysis of the survey responses, several topics were identified worthy of further in-depth exploration, including whether there is a clear route of progression from GCSE for those students with an interest or passion in 'food'. Whilst writers have speculated that progression pathways and status have deteriorated (Rutland, 2020; Wood-Griffiths & Lawson, 2020), first-hand accounts from teachers about their experiences and why this is associated with the removal of A-level would provide valuable insights.

Research Methodology

Situated in the Pragmatic Paradigm, (Tashakkori & Teddlie, 1998, 2010) this inquiry adopted a practical approach to explore what teachers are doing and the consequences of actions. As the researcher for this project is part of the teaching community, it was possible to draw upon a range of approaches, such as teacher survey questionnaire and interviews as well as professional experience to describe and interpret what is happening. As a phenomenologically orientated researcher the research is focused on understanding from the insider's or teacher's viewpoint (Fetterman, 1988).

Using the approach of 'Naturalistic inquiry' (Salkind, 2010; Lincoln & Guba, 1985) allowed an understanding of the impact on the teaching world more closely. This research approach was not intended to prove cause and effect, rather inductively to search for patterns in the collected data, and to offer explanations that describe and interpret the experiences of teachers and activities of specific schools in the context of teaching post 16 qualifications. A case study approach which allows intensive descriptions and analyses of a single event (Merriam, 1998), is an appropriate method to explore and explain the changes, since the A-level course ceased.

Method: the selected sample

A 'purposeful sampling' method (Emmel, 2013) was employed to choose participants. It is also known as selective, or subjective sampling and is frequently used to select 'information rich cases related to the phenomenon of interest.' (Palinkas,, et. al., 2015). 'Participants criterion sampling' was chosen to pick those that met certain criteria intricately linked to the aims of the investigation. (Patton, 1990)

Participants were selected from the one hundred and fifty-seven teachers who agreed to be contacted again after the February 2020 survey. Filters were used across the respondents' survey data to identify those who met certain criterion (n=17). Teachers in schools that offered courses for students interested in pursuing further study in food and who had expressed concerns about changes to progression pathways were selected as they could provide first-hand accounts of the impact of the removal of A-level. The sample criteria included:

- those with more than 10 students who expressed an interest to study 'food' at A-level in 2018 and 2019 (as an indicator of a successful, strong, and established A level course).
- those schools where A-level Biology or Chemistry, or vocational courses (such as Health and Social Care and/or Food Science and Nutrition Diploma) were on offer to students interested in securing a place on a food related degree or career (to examine the claim by DfE that other courses could replace A level Food and maintain progression routes)
- those who expressed they 'disagreed or strongly disagreed' when asked if 'the progression routes had remained the same' since removal of A-level. In the February 2020 survey 71% respondents disagreed/strongly disagreed that routes of progression had remained the same, and 17% agreed/strongly agreed that routes of progression had remained the same. For those that had taught A-level, 78% disagreed/strongly disagreed that routes of progression had remained the same. This sample criteria was used to help examine what specifically had changed in these schools to progression routes.

From this sample of seventeen, eight teachers agreed to participate in further research. The less than 50% response rate could be attributed to COVID19 as it was a fast-changing situation between the first request and conducting the research. (March to May 2020). However, the sample represented views from a range of A-level teachers, including:

- a range of school types (three academies, one faith school, two community-maintained schools and two grammar schools), size of school and location
- a range of previous A-level courses (five taught AQA Food Technology, one taught OCR Home Economics and two taught Edexcel Food Technology)
- one male and seven female teachers, with a range of years of experience of teaching A-level
- six teachers who teach no post 16 course since the removal of the A-level and two teachers who teach Level 3 WJEC Food Science and Nutrition as a vocational alternative to the A-level.

Methodology: data collection

Data collection was designed to be manageable during a difficult phase of COVID19 March-May 2020. Many teachers were not attending schools and were under pressure to reorganise their lessons for home study. Face to face interviews would not be possible and participation time had to be limited. Multi- stage data collection method (Fetters et. al., 2013; Azorín & Cameron, 2010; Ivankova et. al., 2006; Hopwood, 2004) was chosen to include:

1. a short open-ended questionnaire that was completed first (administered by email as a text document)
2. a semi structured interview conducted using video conferencing (See Appendix 1).

The informal nature of the semi structured interview allowed the open-ended collection of data that allowed for individual variations, such as personal narrative, descriptions, observations, and examples, in addition to factual information (such as exam numbers, numbers of students who progressed to universities) and views that were collected via written questionnaire responses.

To make effective use of limited time, an interview guide was used. It ensured that the same information was covered for each participant systematically but there were no pre-determined responses. The interview guide was modified over the course of the interviews, to elicit detail on certain topics that presented themselves as important. (Lofland & Lofland, 1984).

Data collection themes included asking general background information, such as approaches to the curriculum, A-Level courses previously taught, career routes of ex-students; discussing what had changed in the school since A-level was removed; and discussing progression routes to further study and employment and the qualifications now on offer. These themes were chosen to reveal how the subject, students and teachers had been affected. The questions were devised using the author's professional experience of post 16 qualifications policy developments and by formulating follow-on 'probing questions' (Newcomer et. al., 2015) that linked to pertinent February 2020 survey questions and responses.

There were some methodological considerations which may have impacted upon the data collected.

- The interviewer/respondent effect - respondents might give particular responses to impress the interviewer or because of their position within a community. But is also seen that respondents can give greater information to people that are known to them. (Rodriguez et. al., 2015; Smyth & Holian, 2008)
- Knowing the study purpose - Knowing why the research is needed may create particular responses, for example, if the teachers felt that this might lead to a report to influence government to change their decision around A levels. (Unluer, 2012)
- Induced bias - personal prejudices of the researcher. (Morse, 2006)

Method: recording and analysing data

The raw data was collected from pre interview questionnaire responses and full transcriptions of interviews recorded. A thematic approach was taken to analyse the data, meaning that the critical themes emerged inductively. Content analysis from the raw data collected began with 'open coding' (Strauss & Corbin, 1990) using a 'word cloud' facility within the transcription software suggesting frequent key words (see Figure 1). Words, phrases, and activities that appear to be similar were grouped together, notes were made, and categories were created, linking together emerging themes.

As encouraged by Hoepfl (1997) the process was to view the:

'… "big picture." The purpose of coding is to not only describe but, more importantly, to acquire new understanding of a phenomenon of interest.'

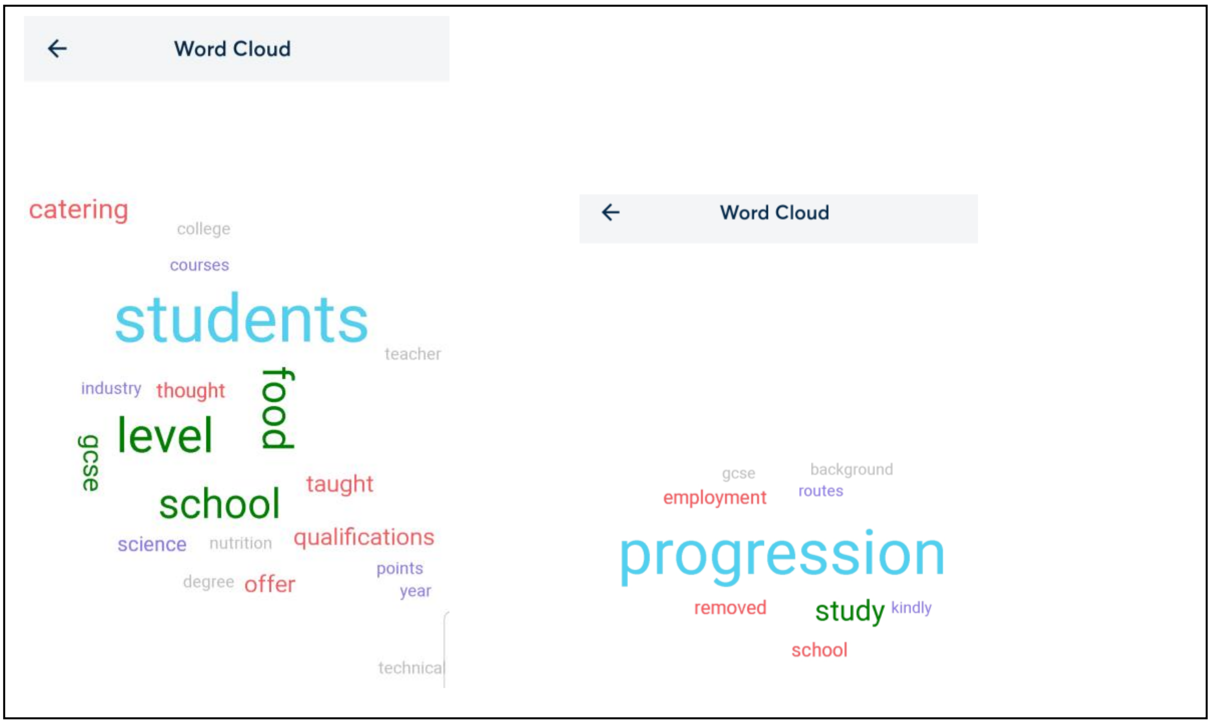

Figure 1. Word Clouds generated by interview transcription software

Some patterns or relationships can be confirmed or verified through the triangulation of multiple data sources (for example, we can compare findings to similar literature and external data regarding exam entries). The multi-stage approach of questionnaire and semi structured interview also meant that information could be checked to validate the data collected, verify the findings, and add rigour to interpretations (Lincoln & Guba, 1986). This was important as there was not time to employ member checks or peer reviews. A review of the multiple data sources was used to challenge any initial assumptions and to seek alternative views or explanations. The final stage was to identify those themes that were central and most useful to the research question.

Method: Ethical issues

This research encounters ethical questions that all researchers face when collecting people's personal accounts and experiences. This included employing appropriate and honest ways of questioning teachers, of analysing data and presenting findings fairly and accurately, as well as protecting the identity of the participants and their schools through anonymity (Lancaster, 2017; Vainio, 2013; Wiles et. al., 2006), particularly as an insider in the community (Taylor, 2011; Perryman, 2011). As the sample were selected from an earlier study (BNF & Food Teachers Centre 2020), permissions from teachers to be approached again for a new inquiry were gained.

The Findings: The Progression Pathway

In general, *three consistent themes* emerged from the analysis of the data.

***Theme 1: Without the A-level course students who would have continued at 11-14 years to GCSE and beyond into higher education and careers in the food sector have lost a vital route*.**

During the interviews, all teachers voiced their concerns about the cessation of the pathway to future study and careers. They described with pride many ex- students who pursued their studies at prestigious Russell group universities and careers with high level positions in the food sector after the A-level course:

> *Some went into food science and technology, product development, food journalism, sports nutrition, international hospitality, lecturing, Ph.D. medicine, dentistry'…. they've ended up being in their dream job.*

Teachers interviewed also recognised its usefulness for high performing A-level students, in supporting a range of roles in preventative medicine, such for GPs and nurses: '*Our local hospital's Dietetics Department was solely filled with our alumni at one stage*'.

The two schools who had replaced their A level course with an applied general qualification alternative (Level 3 Diploma in Food Science and Nutrition) expressed, with disappointment, how this course rarely leads to university or careers in the food sector compared to the previous A-level: '*In the past, we have students that have become food product development managers, food marketing, dietitians…… very few of the Level 3 students have gone onto study food*'. The nature of cohort of students opting for this course appears to have changed and teachers describe how it is pursued by the lower abilities who are not headed for higher education: ' *The course appeals to students achieving GCSE grades 4/5/6 rather than the top grades'. And as a 'top up' subject for those that are resitting English and Maths because: 'it's something they enjoy rather than want to do it in the future*.'

The Department for Education's view that A-level food was not needed because '*a high proportion of universities offering food science and nutrition related courses are looking for students with science qualifications for entry to their courses*' (Department for Education, 2016) was not supported by the teachers who recounted how the A-level gave students a head start on their food degree:

> *When ex-students returned to the school, they always said the A-level food course prepared them well for university study and they were often at an advantage to students who had not studied food.*

Teachers reported that the limited amount of food science and nutrition content in Biology and Chemistry A-levels meant students are rarely taught about the broad range of careers in the food sector during those courses. Without the opportunity to nurture that passion '*it goes out of their minds*', the students are diverted to other interests, and they don't continue on a pathway to food science or other food courses and careers (MAG, 2019; FDF, 2017). Teachers previously linked their teaching closely with Science synergistically to give the course considerable applied learning and that is now missing: '*A-level food greatly improved the understanding of the students who were studying science*'. Teachers described how they used local business links and past students now in the food sector to arrange visits and talks to inspire and raise aspirations about what was possible to achieve. '*A-level was an excellent opportunity to open students' eyes to the huge range of careers in the wider industry that they would otherwise not have heard about*'.

We are desperately sorry for the ones that are keen to do something [in food] , they can't hold onto that keen interest for too long, and its lost which is a great pity because that might be the career that brings some true happiness.

Their views were consistent with findings from other research confirming that subjects taken at A-level are important predictors of university attendance, both in terms of degree course and destination. (Sutch et.al., 2016; Rodeiro, 2019). '*They loved the subject at A-level their interest grew and then they studied it in higher education and went onto careers in food. I do not see that at all now*'.

In addition, the removal of food A-level appeared to have had unintended consequences affecting earlier exam choices for GCSE students too. Teachers reported that parents questioned whether the GCSE is '*worth studying' if there are no courses to progress to: 'At open evenings prospective parents treat it as a hobby and asked where they could find the science department*'.

Without an A-level pathway even teachers with high performing GCSE courses described how the numbers had reduced and attributed this to the lack of progression route:

Not having an A-level is unfortunately sending the message that the subject is not important, not academic and that there is no progression whatsoever. Since Food A-level disappeared, I cannot think of a single GCSE student that I have taught progressing to a Food degree.

Theme 2: The Qualifications Framework does not offer courses to ensure effective progression post 16 for the wide range of abilities and broad opportunities in the food sector.

The Qualifications Framework, published by the Department for Education, is the list of approved and funded examination courses that can be taught in schools and other providers. A-levels are generally the most common learning aim for post 16 students (Zanini & Williamson, 2017). Teachers stressed how few suitable post-16 examination options there are despite the government claiming that there are *several* food science and nutrition courses endorsed by universities. This limited range sets it apart, as other practical subjects, such as PE, has A-level and 29 vocational courses (Spence & MacNamara, 2018). For Food, without this A-level, there are two types of courses available shown in Table 1:

1. Technical Levels in Cookery, Food and Beverage Service and Hospitality
2. Applied General Qualifications in Hospitality and Catering

Table 1: Level 3 qualifications

Tech levels in cookery, food and beverage service and hospitality		
Qualification Number	Qualification title	Size - GLH (Guided Learning Hours)
601/3140/8	City & Guilds Level 3 Diploma in Professional Patisserie and Confectionery (QCF)	384

Tech levels in cookery, food and beverage service and hospitality		
Qualification Number	Qualification title	Size - GLH (Guided Learning Hours)
600/4805/0	VTCT Level 3 Diploma in Professional Patisserie and Confectionery (QCF)	384
600/9005/4	VTCT Level 3 Diploma in Professional Cookery Studies (QCF)	473
601/3139/1	City & Guilds Level 3 Diploma In Advanced Professional Cookery (Kitchen and Larder) (QCF)	555
600/4804/9	VTCT Level 3 Diploma in Advanced Professional Cookery (Kitchen and Larder) (QCF)	555
601/3142/1	City & Guilds Level 3 Diploma In Advanced Professional Cookery (QCF)	785
600/4803/7	VTCT Level 3 Diploma in Advanced Professional Cookery (QCF)	785
600/2244/9	Pearson BTEC Level 3 Diploma in Food and Beverage Service Supervision (QCF)	347
600/4806/2	VTCT Level 3 Diploma in Food and Beverage Service Supervision (QCF)	347
600/2078/7	City & Guilds Level 3 Diploma In Food and Beverage Service Supervision (QCF)	354
500/8209/7	Pearson BTEC Level 3 Extended Diploma in Hospitality (QCF)	1080
Applied general qualifications in hospitality and catering		
QN	Qualification title	Size (GLH)
600/4386/6	WJEC Level 3 Diploma in Food Science and Nutrition (QCF)	360
601/4552/3	WJEC Level 3 Diploma in Food Science and Nutrition	360

Technical Levels in Cookery, Food and Beverage Service and Hospitality

None of the teachers interviewed offered the courses for Technical Levels in Cookery, Food and Beverage Service and Hospitality at post 16. These courses include Level 3 Diploma in Professional Patisserie and Confectionery, Professional Cookery Studies, and Hospitality.

> *The courses are great and have their place but are not comparable to A-level Food Technology in terms of reputation or academic rigour. ….. they do not always appeal to students with more of an academic profile.*

The most common reasons given by the teachers for not offering these courses were:

- The Technical Level courses do not offer progression from 11-14 years (KS3) and GCSE Food Preparation and Nutrition into a broad range of future opportunities, as they are too narrow and craft skill- job focused
- It was not what the students wanted to do as they were pursuing university admission and sought a broad base of 'facilitating' A-level subjects (Dilnot, 2018) rather than a

specific skill-based course. UCAS reports that only 9% students apply to university with a mix of A-levels and BTEC qualifications. (UCAS, 2016)
- Schools do not have the catering expertise, facilities or required timetable to deliver courses more suited to specialist Further Education Colleges.

Teachers were concerned that these courses were so specific to a job role such as pastry chef when many students want to keep their choices open at 17-18 years: '*It's directing them somewhere that they may not necessarily want to go through with at this stage… too specific*'.

Applied General Qualifications in Hospitality and Catering

Two teachers now taught the applied general qualification in Hospitality and Catering (WJEC Level 3 Diploma in Food Science and Nutrition) instead of the A-level. One stated that it 'appeared to be the only realistic qualification that could be taught alongside traditional A-levels'. They explained that it had not been easy to recruit and their numbers had reduced significantly. 'We will be lucky to keep this subject on the curriculum if the numbers continue to reduce'. This reduction in numbers is reflected in nationally as seen in Table 2 which compares the number of candidates entered for past A level (Food Technology and Home Economics) and current Level 3 Diploma.

Table 2: Candidates entered for A level and Level 3 Diploma (https://www.jcq.org.uk/examination-results))

2016 A Level	2416 (source: Jamie Oliver Food Foundation 2017)
2019 Level 3 Diploma	605

These teachers expressed concerns about progression, specifically the lack of challenge for the top end of the ability range and the lack of appropriate choices in the Qualifications Framework. One teacher suggested that the Level 3 Diploma course is not broad enough and does not prepare students as effectively for university as the previous A-level course because there is insufficient 'step up in difficulty [after GCSE], with more technical science and nutrition content needed' .

It appears that schools no longer offer pathways to a range of qualifications that foster potential at all levels in the food sector with its *'…. opportunities for unskilled workers as well as for those highly skilled and highly educated*'. (Graham, 2020). This will impact greatly on the food and drink sector, where one third of the workforce is due to retire by 2024, leaving a shortage of about 140,000 recruits, of which 33% are skilled or highly skilled requiring a degree or postgraduate/PhD (FDF, 2017; Heasman & Morely, 2017).

Theme 3: The A-level course name is a clear academic marker for the subject and with no A-level course on offer the subject standing has diminished in the eyes of headteachers, parents and students.

Parents are familiar with what an A-level exam means and understand its currency for university admission and careers, as the exam has been in the school system since 1951. The past Food A-level was accepted as a science subject for university entrance.

> *Once the A-level was removed, the subject has suffered as it is perceived as having less status as there is no progression… I even have students who did not take the GCSE as there was no progression, so they ask: 'What's the point?*
>
> *The subject now seems to be consigned to a vocational course.*

Of great significance were 6 of the teachers, who despite highly successful past A-level results and popular courses, were not able to offer an alternative as their school simply refused to run any applied general qualifications (such as the Level 3 Diploma). If the course was not an A-level, it was not allowed to be taught in the school.

> *I am slightly annoyed that my school will offer A-level Film studies and A-level Dance but will not allow a Level 3 Food Science and Nutrition Diploma course, which is just as academically rigorous.*

Usually these decisions were made by the headteacher to meet the academic culture of the school and who may associate vocational courses '*explicitly for less able pupils*' (Kelly, 2017). Heads are very aware that choice of qualifications is instrumental in acceptance at the highest tariff universities. This reflects findings of others, for example McMullin and Kulic (2016) claim that '*better schools discourage students from entering vocational paths'* effecting the status of many subjects, as part of what Connolly (2020) describes as the '*polarisation that takes place in discourses around academic and vocational education*', in his study of Media courses.

> *'It was NO! It's an A-level or nothing'.*
>
> *'They are very proud that it's a very academic school and that [A-levels] is all that they offer. And I don't see that changing'.*

Teachers recount how Level 3 Diploma's standing is affected as nationally it is left off reporting the school results and has a different grading system, and how '*the status hasn't been helped with messages from some universities not understanding Level 3 qualifications'* and how *'not being an official A-level …. really undervalues the subject and the hard work the students put in*'.

The two teachers, who offer Level 3 as an alternative to A-level, illustrate the struggle of communicating the equivalence of the Diploma course with parents and senior leaders in the school despite the 'Food Science and Nutrition' title: '*It's the title of it [Diploma], it just doesn't appeal to some of the students that we used to have'*. Teachers went to great lengths to provide convincing information such as comparison tables and letters from universities regarding acceptance:

> *it takes some persuading with parents at open evenings and parents' evenings that this subject is of equal worth to an A-level. Because of its title, many parents and students regard it as a vocational subject…… I honestly think it's just because it's not called an A-level.*

In addition to the unintended consequences of reducing GCSE number, there were significant implications that affected the teachers' careers and standing in the school. As a result, one teacher who is now Director of 6th form recounts how this has affected their career '*senior leaders don't count me as an equal'* and another stated '*just teaching an A-level subject, you* *kind of have more kudos in the school'*. Another seeking promotion was told that '*only teachers who taught A-level would be considered for a middle management position*'. On this basis, the influence of a food teacher across the whole school will be severely limited, with little opportunity to become a senior leader or headteacher.

Discussion

Table 3 summarises the key findings from examining the progression pathway and how this has been changed by the removal of A-level. It shows how policy decisions can interact with practice in schools, creating some unintended consequences and far-reaching changes.

In removing one A-level qualification ministers may not have foreseen that they would need to take action to protect the progression route and position of food in the curriculum

For example, when making a policy decision to remove Food A level:

- Consideration was not given to the lack of food science content in Biology and Chemistry A level examinations, as these new courses had been specified prior to decisions being taken and have not changed retrospectively. Thus, the assumption that those interested in a Food science route would be provided for by the new science A levels did not become a reality.

- Consideration was not given to the upcoming planned vocational qualification reform and how this may impact on the future food progression routes. Nor was it considered whether the vocational courses proposed were effective replacements for Food A level, giving the breadth of experience required, whether they were suitable for teaching in schools and whether they would be acceptable currency to headteacher and parents. High ranking – prestigious universities are less likely to accept applied qualifications. Applied general qualifications are not included in the performance tables for each school. Their contribution to school results is unrecognised and the subject's academic status declines. Two years on, the vocational courses have not been adopted by schools as they are narrow and specific to a trade, and now only one applied qualification offers a route. Teachers have expressed concerns about how the students opting for this route have changed from their previous A level cohorts. The cohort of students shifts away from those destined to university. The increase in lower ability students taking the exam at post 16 reinforces the lower academic status of the subject. Teachers remain on unsure if the qualifications reform will mean that smaller qualifications such as the one remaining course will be replaced by T levels (3 A level equivalent) by 2023 and then there will be no post 16 options available to them.

- Consideration was not given to making Food the only national curriculum subject without an A level, and how this reduce the subjects status in schools. The research report identifies a reduction in GCSE numbers since A Level ceased, as parents question 'where the subject leads to' and teachers describe how this has affected their career and status/standing in the school. Option choice decisions pre 14 years are based on those exam courses that have clear progression routes. Numbers have fallen for GCSE exam. Without A level and strong GCSE numbers we see Food teaching reduced to a one teacher per school, marginalising its impact and growth as an important contributor to the whole school curriculum. There are fewer opportunities to work synergistically with the science team or PSHE teams in schools. The status of the subject is diminished as it appears not to contribute to the 'academic' school culture. The status of the Food teacher is diminished as they cannot contribute to post 16 education and career and school leadership progression for food and nutrition teachers are closed to them and they are less likely to influence the wider curriculum. As a consequence, very few food teachers progress to the senior leadership team, reinforcing the lower status of the subject.

- Consideration was not given to the skills gaps and requirements of the wider food sector at all levels across a wide industry. By 2024 food sector requires 50,000 recruits for highly skilled roles requiring degree or postgraduate/PhD. To limit the broad range of Food career pathways and interests crucially at a time when the UK requires vast numbers of highly skilled postgraduate recruits for the food sector will stifle economic growth.

Unless action is taken soon, these consequences of this policy decision will be irreversible.

Table 3: Policy and Practice reinforcing factors

Policy decisions →	← Practices and impact
Government Policy change during qualifications reform: removing A-level and replacing with Tech Level or Applied General Qualifications	Food and Nutrition is the only national curriculum subject without an A Level Applied general qualifications are not included in the performance tables for each school. Their contribution to school results is unrecognised and the subject's academic status declines. Applied general qualifications are less popular, fewer students enrol and progress to careers, exam boards find them less viable to run – reduced to only one course, which cannot provide a broad base for the food sector. Lack of food science content in A-level biology and chemistry mean less students develop interest in the food sector, careers, and progression to university courses Alumni industry professionals are no longer contributing to teaching and inspiring students By 2024 food sector requires 50,000 recruits for highly skilled roles requiring degree or postgraduate/PhD

	Tech level qualifications are rarely taught in schools, students must choose a specialised full-time Further Education college route at 16 years rather than having a broad range of subject choices
University Course Admissions: Applied General Qualifications are worth 16 UCAS tariff points for a Pass grade, which is equivalent to the lowest grade A-level (E). Applied courses are not accepted by all Universities to be equivalent to traditional academic A-levels.	The cohort of students shifts away from those destined to university. Increase in lower ability students taking the exam at post 16 reinforces the lower academic status of the subject. Option choice decisions pre 14 years are based on those exam courses that have clear progression routes. Numbers fall for GCSE exam. High ranking – prestigious universities are less likely to accept applied qualifications.
School only offers A-level qualifications in the 6th form due to its academic school culture.	Status of the subject is diminished as it appears not to contribute to the academic school culture Status of the teacher diminishes as they cannot contribute to post 16 education. Career and school leadership progression for food and nutrition teachers is inaccessible and they are less likely to influence the wider curriculum. Very few teachers progress to the senior leadership team, reinforcing the lower status of the subject. Fewer opportunities to work synergistically with the science team in schools.

Conclusion and Recommendations

Food appears to be in a fragile position in post 16 curriculum. It is the only national curriculum subject without an A-level pathway to university and further study. Schools offer non-A-level courses less frequently as there is uncertainty around course equivalence, and this has resulted in an overall reduction in the numbers studying post 16 food courses. Level 3 qualifications are now focused solely on the hospitality and catering sector with only one applied general qualification. The Department for Education claim that there are several high-quality vocational qualifications available and applied general qualifications endorsed by universities is disputed by this research. Opportunities for broader areas of study that encompass food science, nutrition and dietetics and food technology have been removed. This has meant that now fewer students access broader career pathways and interests crucially at a time when the

UK requires vast numbers of highly skilled postgraduate recruits for the food sector. Teachers made a strong case for why a new A-level course should be developed:

> *I don't want to go back to food technology, don't want to go back to home economics, but I think there is an opportunity to do something really exciting and we can do something different, that could really flourish.*

In the field of Home Economics and Food and Nutrition curriculum this inquiry has added valuable insights into the consequences of becoming a 'vocational subject' and how ministerial decisions to reduce exam choices have far reaching consequences, many of which may be unintended.

The decision not to offer Food Technology or Home Economics at A-level was caught up in a political drive to promote cooking skills and a limited view of its 'academic worth' in the constant battle for credibility and status. (Tull, 2018; Attar, 1990). The subject has been unable to shake off the prejudices that are ingrained in its history, when it was introduced as cooking skills for the poor working-class girls and failed to be accepted as part of the liberal education system promoted by our universities, that still relegates practical, 'domestic' and applied subjects to second place.(Tull, 2018)

The next step is to ensure that the government policy makers are aware of the results of the research, particularly when the findings can be combined with the February 2020 survey. These findings, together with evidence from universities and the food industry, who have been detrimentally affected by this policy decision, provide a convincing argument to urgently improve the progression pathway to meet the needs of young people.

Recommendations

Based on the February 2020 survey results and this research project, it is recommended that the following be undertaken:

- Hold a formal review to explore the potential interest and demand for the reintroduction of a 'food' A-level, taking into account changes that have happened in GCSE qualifications, introduction of T-levels, review of vocational qualifications, teacher workforce numbers, student interest and demand, university and employer need, and awarding organisation interest. If sufficient interest, a working group to develop draft subject content for consultation should be established.
- Ensure that all schools (including academies and free schools) offer a minimum level of food and nutrition education at Key Stage 3 (based on the recommendations made from the Food Education Learning Landscape research, 2017), and offer routes of progression at Key Stages 4 and 5 where there is need/demand.
- Review the number of secondary school 'food' subject specific teachers entering the workforce to ascertain whether there is suitable succession planning to ensure the continuation of high-quality food and nutrition education in schools. In addition, ensure that trainee, newly qualified and current 'food' teachers have the subject specific skills and knowledge.

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Industrial Design Education: A Research on Generation Theories and Change in Turkey

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Abstract

Due to their birth at the same time interval, according to the generation theories based on the idea that the individuals who were exposed to the same social, historical, and cultural events and thus have common experiences, similar attitudes to similar thoughts and behaviors, nowadays five generations, which are the Silent Generation, Baby Boomer, X, Y and Z Generations, live together. Each of these generations exhibits different tendencies in matters of work, family, and education because they encounter with different historical events, social relations and technological developments that help to see and make sense life from a different angle. Considering the individual who performs the design action and is affected by it, and relationship with the social structure due to the nature of the design, it is thought that generational differences will create similar differences in the approach to design action. Therefore, design education as a reflection of design practice will be affected by this difference. Thus, in this study to examine the change dynamics of industrial design education in Turkey within generations theories, in-depth interviews were conducted with different generations' lecturers working in departments of industrial design in Turkey and data were compared within the framework of generations' theories. As a result of the study, it was seen that changes in education parallel with characteristics of the generations due to changes of the generation of both the lecturers and the students. It also put forward the importance of being able to create a structure of education that is open to support changes.

Keywords

Generation Theories, Design Education, Generation Difference

Introduction

As well as the use of the concept of generations which draws attention to generational differences in social life throughout history, it is used in academic areas such as sociology, psychology, philosophy, political science, and demography. The sociological meaning used in this study describes individuals born in the same period, affected by the same historical events and who have common characteristics with their common experience. According to Jaeger (1985), interest in generations research began to examine how generations' historical movements and changes were actualized. Subsequently it gained popularity with the development of technology and the information age. With increasing interest, generational theories have been handled by different authors and used to explain human behavior in different fields. The studies reached within the scope of this study were classified as shown in Figure 1 and a concept map related to the field of generational theories was created. The first scientific research on generations started with Comte, and the flow of regular publications started with the work of Francois Montre (Jaeger, 1985). In this sense, two important contributions to generations studies were provided by Karl Mannheim (1928) and Jose Ortega y

Gasset (1923). In the recent past the generation theory developed by Strauss and Howe (1991) brings a new perspective to generational studies. As seen in Figure 1, many studies have been carried out on the basis that these authors built.

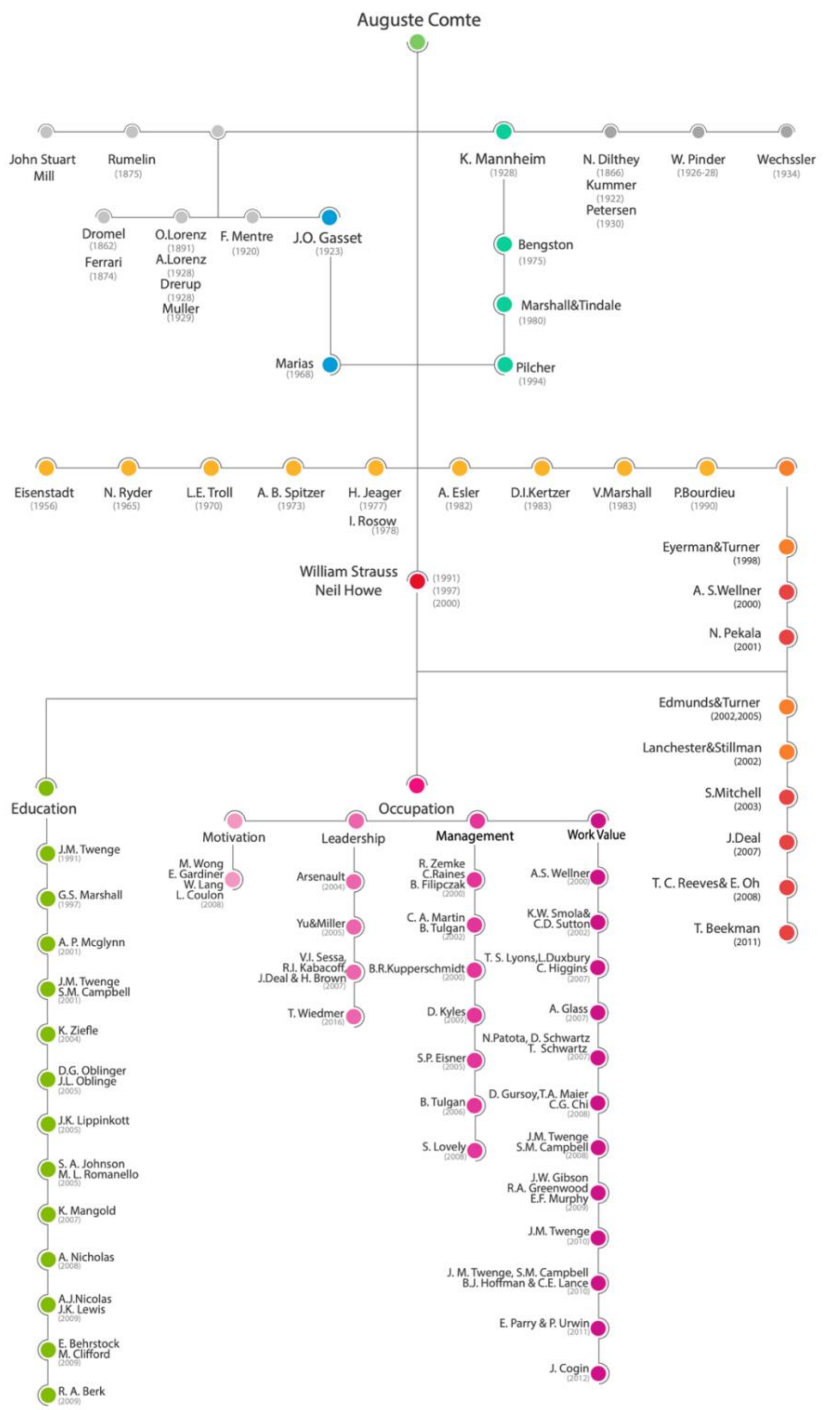

Fig. 1 Generation Theories Conceptual Field Map

According to generation classifications, five different generations, that are the Silent Generation, Baby Boomer, X, Y and Z Generation, live together nowadays. Each of these generations has different characteristics, attitudes and behaviors shaped by different historical events and experiences. As seen in Figure 1, the range of research related to these differences has diversified in recent years such as business values, motivational factors, education life, approach to technology and consumer behavior. However, despite popularity of the subject, relatively little academic work has been done on the verification or rejection of generational differences (Cennamo & Gardner 2008; Lyons et al. 2007; Sessa et al. 2007).

Generation theories make an important contribution to theoretical framework of this study and set boundaries when dealing with changes of industrial design education because it reveals the differences between generations by determining the reasons for each generation to develop their own identity. While varying living conditions, culture, social environment, technology, user expectations and consumer characteristics created changes in design discipline, social and historical events change individuals who realize designs and expect to benefit from this. Therefore, the change in the qualities of the individual who realizes a design and expects benefit from it will create differences in the approach to the design action. As a reflection of this, we think that design education will be affected by this change. According to Prensky (2001), educators today strive to communicate with students who speak different languages, and design of the current education system is not suitable for present-day students. In design education based on a master-apprentice relationship, communication between the lecturer and the student requires a lot of attention. Design education is characterized by continuous dialogue; students learn to share information during communication with each other, a lecturer, or jury members. Since the quality of this communication is related to different experiences, educational life, learning approaches, communication styles, social features and business values of each generation, generational differences are manifested by one-to-one interaction in design education. At the same time, the change in the human resources of the departments depending on the demographic characteristics brings together individuals from different generations to work together and to be in contact with students from different generations. At this point, understanding the generational differences is important for design education, especially to increase the quality of communication with students. According to Chen (2016), how to increase communication, interaction and efficiency between instructors and students is worth studying. Nowadays, most university students who are the subject of this communication are Generation Z who are relatively new to higher education and Generation Y. However, In Turkey, although most of the human resource of departments of industrial design is Generation X, the academic staff is also composed of Silent Generation, Baby Boomer and Generation Y.

In addition to generations of students and instructors changing, design practices are also changing to find solutions to new problems and questions with new epistemologies and ontologies that will help us understand current situations (Forlano, 2017). This change directly affects design education and requires new and flexible models that can deal with future practitioners' needs, unknown markets, and new cultures (Moreira et al., 2016). Until the mid-90s, in industrial design education, whereas the design studio model that evolved from the Bauhaus continued, subjects such as market research, materials and production techniques, graphic design, computer-aided drawing and ergonomics were included (Budd 2011). With the promoting of mobile technologies and understanding that the value of design was not only related to concrete objects but also to its role of shaping experience and lifestyle surrounding products, in 2000s the emphasis on the relationship of design with human and social effects of digital technologies created new goals and outcome for design. Since the mid-2000s, topics such as participatory design studies, design research, sensor technologies and programming for interaction have been included in design education (Budd 2011). New applications emerged with developing digital and mobile technologies that affected design culture and caused design education to change too. With the including of technological tools in design education, virtual design studios, distance design education programs, interdisciplinary and multidisciplinary applications have started to come into question. Online education practices have become an increasing trend in design education (see Chen & You 2010; Renda & Kuys 2015; Toh et al. 2015). With the development of technology and rise of the network society, resources that students feed have diversified. In addition to traditional resources, student learning has been increased through social media (Renda & Kuys 2015). As design education progresses towards a networked mentality of different knowledge areas and levels of interaction, a sociological approach to education is required. In this context, it is aimed to examine the change in industrial design education within the framework of generational theories, depending on both the change of generations of students and the diversification of the human resources of the departments with individuals from different generations. And thus, it can show how design education can be more productive for the new generations, by understanding the features of industrial design education that make learning more meaningful and effective, along with the educational values of different generations. At the same time, it is aimed to contribute to the understanding of individuals from different generations to increase the quality of communication, which is important in design education based on the master-apprentice relationship. Thereby we think that this study which focused on the different approaches that shaped design education of different generations of students and lecturers contributes to understanding communication between lecturers and students, and students' learning processes and learning resources.

Theory of generations

Mannheim (1952), associating concept of generation with concept of class, used the concept of generation to define people who share similar experiences, share common values and culture in same age group in a common position in the historical and social context. Thusly, a generation refers to an identifiable group that shares the years of birth, age position, and shares important events experienced during critical developmental periods of a society (Kupperschmidt, 2000). Accordingly, it is a social creation rather than a biological necessity (Sessa et al. 2007). According to Strauss and Howe (1997), it is the sum of people who born at the same time, share a common place in history and thus have a common personality. Therefore, individuals born in the same historical period and socio-cultural context have similar thought structures, experiences, and behaviors with effect of the same historical, political, economic, and social events, and each generation creates its own generation personality with impressions of shared experiences in their youth years. (Mannheim, 1952). According to Zemke et al. (2000), a defining moment that captures the attention and emotions of millions of individuals during the formation phase of a generation helps to identify the characteristics of a generation. Wars, communal, cultural, social, political, and economic changes, and technological developments are examples of these important events (Zemke et al., 2000). Thanks to these events, each generation shares a common past that creates similarities.

Similarly, generational differences are the result of different historical conditions experienced by generations (Smola & Sutton, 2002).

Generation researchers classify generations by focusing on the factors that cause generation differences which individuals encounter depending on their year of birth. With these classifications, generations are named with a name suitable to the generation identity which they have acquired depending on the defining moments they have lived (see Table 1). In addition, date intervals for the birth years of generations are defined differently by different authors according to the period, society, individuals, and events encountered (Reeves and Oh 2008). Strauss and Howe (1991) determined the boundaries of generations by year of birth and used the life stages a person passes through to help define the length of a generation. Thus, the length of a generation cohort is defined in periods of twenty two years. But there is no definite limit defined for the transition from one generation to the next when classifying the generation. Depending on the events they experience, the thoughts and behaviors of the members of a generation, as well as their value judgments and attitudes, helps researchers understand the boundary between generations. The historical position of a generation is determined by important historical events, social messages, family structure and technological developments that occur in childhood and early adulthood (Arsenault 2004; Kupperschmidt 2000; Strauss & Howe 1991, 2000; Zemke et al., 2000). According to Strauss and Howe (1991), generations bear a unique signature of past moments. In this way, individuals who were born in the same period and shared a common time in history, constitute a generational personality with important events, beliefs and attitudes that affect them especially in adolescence and early adulthood, defined as the years of formation. The concept of generational identity gains importance for effective definition, recognition and understanding of each new generation (Codrington & Grant-Marshall, 2011). A generation's identity is the set of common behaviors and attitudes that a generation displays throughout its life cycle (Strauss & Howe, 1991). Generational personality is used to define a generation and find the boundary that separates it from other generations. According to Zemke et al. (2000), although every individual does not fully fit the personality profile of their generation, all members of a generation are deeply affected by their generational personality. Even so, when generalizing about a generation, possible definitions and classifications are made with the assumption that not every individual in this generation will necessarily show the same tendencies (Strauss & Howe, 1991).

According to most researchers, country, and national culture play an important role in generational classification and generational identity is shaped by the cultural structure of a society. However, with the increase in communication and interaction through technological advances, global generations emerge (Edmunds & Turner, 2005). According to researchers who advocate the existence of the global generation concept, young people belonging to one generation are more similar to each other day by day (Lower, 2008). Generational similarities reduce differences related to race, ethnicity, or economic components. On the other hand, the differences between the generations become more evident due to changing social structures and technological advances. This situation shortens the length of the generations and causes them to be separated from each other with clearer boundaries. In this context, the different generation characteristics encountered in accordance with the generation classifications are presented as in Table 1 within the scope of the literature reached in this study.

Table.1 Generational Features

Generations	Silent Generation	Baby Boomer	Generation X	Generation Y	Generation Z
Date of birth	1925-1945	1946-1964	1965-1980	1981-2000	2001>
Formative Events	War and economic instability	Economic growth and prosperity Developing education system Increasing urbanization and social change	Familial, social, and financial insecurity Diversity Lack of strict traditions Technology and information Increasing divorce rates	Technological advances Terrorist attacks Violence Income inequality	Culture that with high technology products and social networks Demanding and impatient Wars Terrorism
Family	Traditional immediate family	Traditional concerned family Spoiled child	Divorced parents Working parents Neglected children	Helicopter parents Protected child who consults and trusts his family in all matters	Second type helicopter parents that is extremely interested, doing whatever their children want Older parents
Characteristic Features	Loyal Formal Well-disciplined Patient Devoted Unselfish Thrifty Compatible Obedient Hardworking Honorable Patriot Respectful to authority Depending on traditions and moral values	Optimist Idealist Selfish Rebel Prescient Competitive Ambitious Career-oriented Workaholic Rational Contender Responsible Questioner the status quo	Skeptical Wry Skilled Informal Confident Self-contained Sensible Accommodating Compliant Self-reliant Fun-oriented Creative Pragmatic Tolerant to differences Suspecting and questioning of authority	Realistic Optimistic Global Ambitious Technology-prone Good team-player Success and fun focused Selfish, Confident Social Conscious Open-minded Impatient Demanding Result-oriented Tolerance to differences Willing to take responsibility to make change and difference Accepting authority but does not trusting	Global Technology-dependent Loyal Thoughtful Compassionate Open-minded Result-oriented Good-natured Diligent,Innocent Risk-avoiding Individualistic Innovator Impatient Discontented Creative Tolerant to differences High-motor skills Lack of social skills Emotionally fragile
Values	Work hard Do with less Moral values Customs, and traditions	Idealism Health and wellness Self-improvement Personal pleasures	Resisting their parents Freedom	Moral values Race and ethnic diversity	Race and ethnic diversity Supporting the disadvantaged population
Attitude	Control-command Sacrifice	Optimism Workaholic Materialist Believing that you can change the world	Skeptical Independent Not belonging to any group Focus on multiple goals	Hopeful The rules are for breaking	Diligent
Technology Perspectives	No technology, no adaptation Uses for very rare work	Far from technology adaptability difficult Technologically conservative Uses for work when needed	Compatible with technology Technology provides convenience Uses often for business and social life	Indispensable, High relationship with technology, growing up with it Uses in business and social life for your needs	Technology is an important part of natural life 24/7 online Uses to meet all kinds of requirements
Communication Preferences	Face to face by Phone	Face to face by Phone	Email SMS	Email, SMS Instant message Social networks	Instant message Social networks 24/7 online
Learning Characteristics	Disciplined Very strict education system	Learning in the lesson	Fast and efficient learning	Based on search engines Experiential	Result-oriented Impatient Multitasking

	High educational success	Learning with individual experience The best learning if the topic is of interest Freedom of expression Waiting for positive support for their efforts Formal Structural Technical Data/Evidence based Lifelong learning	Learning the things that will benefit Flexible learning times Practical Educational Comfortable Interactive Applied Case-based They don't want to spend time Learning something they don't need	Kinesthetic Short attention span Impatient Visual literate Communication expectation Weak time management Frequent and short-term feedback expectations Success and grade-oriented Want learning with real life experiences Bored from traditional teaching methods	Lack of attention, Effective use of technology Personalized learning with graphics Primary source internet Education at home before school Longer education Instruction and guidance expectation They feel pressure for success and are afraid to disappoint others He wants to make a difference, but not determined
Learning Environment	Class	Class, Calm environments	Comfortable environments	Whenever they want, wherever they want	Distance learning
Suitable Learning Activities	Keep to strict rules	Detailed information Take notes Personal stories about the subject of the lesson	Independent learning Detailed study guides and test comments that focus on how to test	Activities related to real world Creative, innovative, interactive exercises Group activities Technological innovations Programmed instructions	Activities that trigger creativity Dramatization Storytelling Use of technology Focus on visual elements Clear homework definitions
Work Values	Live to work Avoiding risk Follow the rules Work hard Mission before fun Strong work ethic Job security Long-term career Long hours linear operation at the place and time expected from him Formal and one-to-one relationships with colleagues Honest business honest salary	Living to work Workaholic Competitive Idealist Respectful to Hierarchy Personal development and job security Permanent and strong business ethics Education for business success A showy career Seniority-based promotion Proving yourself by working long hours in the office Face-to-face formal communication Personal relationships with colleagues	Work to live Unfaithful Creative Entrepreneur Result-oriented Fun at work Instant feedback and rewarding Lifelong learning Career options evaluation Workplace; office, home, Flexible working style and less hierarchical structure, seeing colleagues as friends Direct and electronic communication	Work-life balance Entrepreneur Innovative Multitasking Working with fun Education at work Advanced technology Multi-career Getting more experience before work life Short-term and flexible work Determining the place and time of work Communication with informal Social relationships with colleagues Expect immediate feedback and appreciation	Frequent job changes are expected Working wherever and whenever they want
Teamwork	They like to work with loyal teammates accompanied by a strong leader and when told what to do	They like teamwork collaboration, and decision-making, but they are afraid of losing their place in the team	Doesn't like teamwork Want to be evaluated with their own performance	Like collaboration and teamwork Like diversity	Not suitable for teamwork

Source: (Arsenault, 2004; Beekman, 2011; Berk, 2009; Codrington, 2008; Cogin, 2012; Deal, 2007; Dziuban et al., 2005; Eisner, 2005; Gibson et al., 2009; Glass, 2007; Hampton & Keys, 2017; Howe & Strauss, 2000, 2007; Johnson & Romanello, 2005; Kupperschmidt, 2000; Lancaster, 2004; Lancaster & Stillman, 2002; Levickaite, 2010; Lyons et al., 2007; Lyons & Kuron, 2014; Mangold, 2007; Martin & Tulgan, 2002; Mcglynn, 2001; Mohr & Mohr, 2017; Nicholas, 2009; Oblinger & Oblinger, 2005; Parry & Urwin, 2011; Pekala, 2001; Prensky, 2001; Reeves & Oh, 2008; Sessa et al., 2007; Smola & Sutton, 2002; Strauss & Howe, 1991, 1997; Sullivan et al., 1997, 2009; Tapscott, 1998, 2009; Tolbize, 2008; Twenge, 2009; Twenge et al., 2010; Wiedmer, 2015; Zemke et al., 2000; Zopiatis et al., 2012;).

Method

The aim of this research is to examine the change of industrial design education depending on both the generations of students and the diversification of departments' human resources with individuals from different generations. Accordingly, first the infrastructure of research has been established examining concepts, theories and past studies related to the research topic. Studies addressed generational differences in the academic field were conducted with the help of interviews, focus group studies, surveys, and meta-analysis methods. When handling the structure of studies using qualitative research techniques (see Arsenault, 2004; Broadbridge et al., 2007; Gursoy et al., 2008; Kunreuther, 2003; Nicholas & Lewis, 2009; Rodriguez et al., 2014) among the studies examined within the scope of the literature research and the quality of the data obtained, it was concluded that qualitative research techniques, which are preferred to systematically examine the meanings arising from experiences of individuals (Ekiz, 2003), are a suitable method in order to understand the values, attitudes and thoughts of individuals from different generations towards education in this study. Thus, primarily human resources of the department of industrial design in Turkey were determined. Then, by using the purposeful sampling model (Maxwell, 1996) which aims to collect in-depth information about the event, situation or person that is the subject of the research in line with a purpose and the semi-structured interview technique, interviews were conducted with the academic personal as it was thought that they could competently evaluate the change in education over a long-term. Selection of participants was carried out with the inclusion of enough academic staff from each generation, after determining the human resources of the departments. Yet, parallel to the general structure of the human resources of the departments, most of the participants were Generation X lecturers. The most important criterion in determining the participants was that the undergraduate graduation of the instructor is industrial design. This was considered to be important for the participant to be able to evaluate his/her own student status, the current educational process and student profile. However, due to the founding faculty members in Turkey containing graduates from architecture or interior design, in order to better understand the process since education started, exceptions were made, even if participants were not a graduate of industrial design but had worked in the department throughout his/her career. In addition, while selecting the participants, attention was paid to their active work in universities to discuss current education dynamics. But, for the reasons stated above, two retired academic staff were also interviewed. In addition, the diversity of the institutions where the participants graduated and worked was also taken into consideration. For the interview, an invitation letter and interview questions were sent to the instructor by e-mail. Instructors, who could not be reached via e-mail, were reached by phone and an appointment was requested. This process was repeated to get enough participants. Thus, interviews were had with 24 academic staff who responded positively to the interview request.16.7% of the participants were Silent

Generation, 25% was Baby Boomer, 50% was Generation X, and 8.3% were members of Generation Y.

With the interviews, it was aimed to get the opinions of individuals from different generations about the change of design education based on students, curriculum, and instructors. Interviews for this purpose consisted of 13 open-ended questions: change in student profile, curriculum changes and teaching methods, and work-related attitudes and behaviors of different generations of academicians. During the interview, first, information was given about the purpose of the research and the scope of the subject. On the interviews, the order in the questionnaire was adhered to, but was flexible about the answers of the interviewee. The interviews were conducted with twenty-four lecturers from fourteen different universities in four different cities, namely Istanbul, Ankara, Izmir, and Eskisehir. Twenty-three of the interviews were conducted face-to-face and at the participant's workplace. One interview was made via Skype. In addition, at the request of two participants working in the same institution, a meeting was held with two faculty members at the same time. Interview times ranged from approximately 45 minutes to 2.5 hours. The interviews were recorded with a tape recorder, with the permission of the participants. Since one interviewer did not give consent to be recorded, the data were recorded by taking notes during the interview.

During the analysis phase, the audio recordings were analyzed and written down by the researcher. The analysis of the obtained data was carried out with descriptive analysis and content analysis method using NVivo12 Qualitative Data Analysis Program. In the analysis process, first, to examine the issues covered by the data from a holistic perspective and to determine the prominent points in the interviews, the interview records transcribed in writing were examined in detail. Then, appropriate themes were assigned to sentences or passages, considering the questions asked. In order to systematically encode the data and to see the connections between different parts of the data, the written interview records were transferred to the NVivo12 program, the themes were determined, and the coding process was performed. First, the answers of the same generation lecturers were grouped and then the classification was made according to the determined themes. After the first coding process was completed, the quotations under the same code were read again and if necessary new codes were assigned, similar codes were combined, or the places of the quotations were changed. As a result, the results were organized systematically, quotations representing the results related to the context were selected and the codes were supported.

Results

Education Approaches

It is the first common opinion that the most important factor affecting the approaches of generations in university education is the quality of their pre-university education. It is thought by the participants that the pre-university education of the Silent Generation and the Baby Boomer Generation is more qualified, and this is reflected in their university education. Another point those lecturers emphasized was the role of students and lecturers in education. It was stated that a more student-centered education approach was adopted in line with the approaches of Generation Y students and Generation X instructors. While A Generation X participant said, “In our time, the teacher had more power. Now the student is in the foreground. So, the lecturer has to think. If I do this, how does the student behave… Something is done considering the student's reaction.”. Another point expressed is that the Generation Y students wait for more instructions and avoid taking initiative. A Generation X participant expressed this general opinion as: “Students have become more demanding. So they said, give us more information, how we will design it. This happens by saying that the student cannot take the initiative, let's direct them…” The participants of the Silent Generation and Baby Boomer stated that they were more demanding in terms of information when they were students. A Silent Generation participant stated this situation as: “…there is no demander, like the difference between student and pupil. So, they don't demand.” Another point that the participants emphasized is the expectation of the new generation students to set out defined rules. A participant in the Baby Boom Generation expressed this expectation of the students as “For example, one of the desired things in recent years is books… It is the first time in my 36 years of professional life that I encounter groups of people who request books…”. In addition, there was another common view that current students showed a result-oriented approach. A Baby Boomer Generation participant said, “…In our time we were process oriented, learning was more important than results. Now the results are important… they want to ignore the fact that design education is a dedication, a process, and in terms of its requirements, it includes more work, the processes of working together in a fast, collaborative and hands-on manner.” expressed in the form. Another member of the Baby Boomer Generation spoke of his student life, “In our time, the student was responsible for learning. His goal was to learn. He said I did not learn this lesson well this semester, I would take this course again next year. Because the learning focus was process-oriented. The current ones are results oriented.” A Silent Generation lecturer who believes that the education system has become less disciplined in this way said: “The idea that students' demands will decrease when an oppressive order comes is very wrong. On the contrary, if the pressure increases, the demand increases. The student demands something that does not exist, it is a beautiful thing. The only thing that can carry his teacher forward is the student, no other factor…” Therefore, the Silent Generation, who grew up in a strict education system, believes that this lack has negative consequences. In addition, from the answers of the lecturers, it was understood that the previous generations saw design education as a way to realize themselves. A Generation X participant said, ““Ours was more of an existence. Here, however is a "Survivor" situation, the captain who saved his ship...”

Research

Although data on the attitude of the Silent Generation towards research could not be obtained, the general opinion of Baby Boomer and Generation X instructors is that the students' desire for research decreases with the transition to Generation Y. Participants think that the biggest factor in this regard is technology, that the relations of new generation with technology provide easier access to information but these generations are reluctant to evaluate it. A Generation X member said, “So the information is always there. You can reach it whenever you want. Maybe there's a relief that he gives right now... Maybe it's more difficult because you have access to a very wide range of information. So, you have to scan through all that information.” and drew attention to a difficulty experienced by the students during the research phase. Another common opinion was that the students did not question the reliability of the information they obtained over the internet and needed guidance in distinguishing reliable information. Another common attitude about the research has been the gradual decrease in the understanding with meeting with the user, observing and identifying the problems in this way, in the studio lessons. A Generation X instructor expressed this common opinion as follows: “Now everything is on the internet. There we encounter all the miracles, all the truths. And so everything is based on getting the result the easy way with the least amount of hassle.” A Baby Boomer Generation participant talked about his student period and that this situation is gradually decreasing as follows: “It was more research-oriented in the past. There are more possibilities for research now, communication is much more important... In our time, it will be produced, is it produced, where is it produced, who produces it, how much is it produced, what are the conditions for production, you would research everything. Today, there is a more productive environment such as the internet, it is more common than before, but the students are not willing…”

Communication

The expressions of the instructors revealed that the development of communication technologies and the ability of new generations to use them differentiated the interaction between students and instructors. While the lecturers of Silent Generation and Baby Boomer stated that they prefer face-to-face communication, Generation X lecturers also stated that they preferred e-mail to communicate with students regarding the lessons. The opinions of the participants revealed that the new generation want to communicate with digital technologies anywhere and anytime. In particular, Generation X lecturers stated that they have created certain platforms to give criticism over social networks in order to satisfy this need of Generation Y, who expect immediate feedback on any issue related to education. Instructors also stated that Generation Y students could follow an event, a designer or be aware of educational opportunities anywhere in the world through social networks. In addition to this, another common view expressed by the instructors was that, in parallel with the view that they communicate and socialize through technology, the interaction of students at different universities with each other increased and they also used this to conduct joint studies. A generation X instructor said: “Actually, they want to take the initiative. They want to do something, and they use technology for that. They are doing workshops. Students from different universities come together… In our time, everyone used to do something in their own school.”

Learning Environment

Lecturers agree that classroom study habits are gradually decreasing, and Generation Y students expect flexibility in their decision to work wherever and whenever they want. A Baby Boomer lecturer said, "There is a student profile who does not say that I will do it here and that I do it wherever it is." Another Baby Boomer participant said, “I cannot follow the habit of working in the classroom as I used to. So, it is not possible to keep children here". Participants think that the most important factor that triggers this habit of students is the communication established through technology. A Generation X participant said, “Now students actually think that everything in life is actually a YouTube video, and they can do it by watching it”. In addition, it has been frequently stated that internships, competitions, workshops, student exchange programs and student communities create an alternative learning environment for Generation Y students.

Technology Impact

The responses of the lecturers revealed that technology creates a lack of concentration, especially for Generation Y, but enables multitasking. A Generation Y instructor explained the students' lack of concentration due to technology as follow: “They certainly can't adapt. You will draw a sketch, but as soon as you put the phone next to them, the event ends. Because something is constantly burning from there. When we talk among ourselves, we see the biggest problem in the absence of a line of thought. Because he has a phone in classes, and the moment he looks at it, he stops listening to you." It is frequently stated that technology is a part of the education life of these students and the tools and equipment used by students change. While a Baby Boomer lecturer express the general view on this subject as follows: “Of course, they are more open to technology, so it's a part of their lives. They also use it for education. I mean, for example, nobody takes notes anymore, takes photos of what we write on the board…”, A Generation X lecturer said: “I call the programs used by the students a holy program. When the Holy program does not allow, you cannot do anything. Of course, the tools in your hand direct the designs of the current students, but in our time, our imagination was your guide. Because you were drawing by hand. But now he can't do the model…. the program didn't allow it or says it didn't happen while modeling here”. However, most of the lecturers stated that technology changes the learning environment of students and new generation students prefer an independent learning style. In addition, the other common opinion expressed by the instructors was that the changes in the technologies experienced by the current students and their interactions with the products created a dilemma for design education, that they differed from previous generations in terms of looking at products, and that the changes in education did not occur as rapidly as technological advances. Therefore, it has been revealed that students need instructors who can mediate with technological developments in order to keep up with this, and that instructors need to update themselves. A Baby Boomer Generation instructor said, “Some exercises that we can accept as educational trainers are no longer valid. Because that technology no longer exists. Even if we reveal this, it does nothing but alienate students. Dysfunction arises, motivation falls...”

Study Skills

From the expressions of the lecturers, it was understood that during the transition from Silent Generation students to Generation Y students, shortened their concentration time, increased multitasking habits, and especially the close relationship of Generation Y with technology was effective in this case. While a Generation X participant said about students' multitasking skills as follows, “…They use the program with their laptops. At the same time, they surf on the internet with their tablets. They also hang out on social media with their smart phones…” another Generation X instructor said, “Previously, students were able to concentrate on one thing and do it... Now, there are so many options, and I think they just scatter through them little by little without doing any of them completely." Another topic pointed out by the instructors is that students' time planning and discipline skills gradually weaken. A Generation X participant expressed the consensus on this issue with the statement “They do not use the time properly, they cannot manage the process…In other words, most of them do not have the ability to live with rules and discipline”. In the transition of students from the Silent Generation to the Generation Z, another issue the academic staff underlined was that, willing to spend time while doing a job gradually decreased. A Generation X lecturer said, "The convenience, demanding life and being easy to achieve results in life, have also reduced the effort in the operation of a project". Another issue raised regarding working skills is group work. According to the majority of the participants, Generation Y students are not prone to group work due to their individual attitudes compared to other generations. A Generation X participant said, “Group work becomes increasingly difficult at the point where so many different people, lifestyles and everyone come together with a strange certainty.” As a Generation Y lecturer said, “I see that they approach them individually. Maybe after our competitive education system in high school, individuality is very dominant here as well. Frankly, we have a hard time breaking it. So I see that they are not very inclined in the group project.”

Education System and Curriculum

According to the statements of the lecturers, it was understood that the changes in the education system and the curriculum were shaped deliberately and slowly with little effect, according to the student profile. While a participant from Baby Boomer, expressed this situation as follow: "The change of the student is also a data for the design education here.", instructors think that it varies more depending on the structure of the university and its human resources. However, considering the factors affecting design education and educational strategies, it was a shared idea among all participants that education should adapt itself. A Silent Generation lecturer comment: “It is not possible for you to think as you thought in the 70s and 80s and to plan your education accordingly. Lifestyle and working conditions have changed, speed has entered life. Design thinking, that is, design work is changing depending on what comes up when analyzing the needs of the user. Accordingly, education should of course be re-planned.” As too, a Generation X lecturer said: “Actually, generations of students change, and this registration is taken… It becomes the general characteristic of the incoming student, that is, of a generation, and that characteristic shapes how you will carry out your program.”

Courses and Methods of Teaching

According to the lecturers, changes in the education system are due to new topics on the agenda in the field of design in the world, Turkey's local conditions, changes in the expertise of human resources, and the current student profile. And it takes place on a course basis depending on the content and rarely on the teaching method. A Generation X lecturer said this consensus was “It is necessary to change it somehow. But it's more about the course names and contents. There are no radical changes in the way of teaching. I can only see topics changing. A new generation should come after us. So, we are still using Generation X methods, changing the subjects". In addition, it has been frequently stated that the change of design tools and production methods due to the development of technology has an effect on the change of lessons. A Generation X participant said: “The design history, design sociology course may not be updated very much. But the material lesson, the production methods lesson is changing. Because in this sense, life is changing, life patterns are changing, instructional systems and engineering are changing". Another Generation X lecturer said: “Technical drawing is changing. Computer classes are changing. The material and production technology courses changing. There are also unchanging lessons. The basic design does not change. Because the fundamental in the design does not change, so there is no new perspective. Therefore, the critical thing among the changing lessons and the unchanged lessons is technology. The lessons that it influenced develop or disappear, something else takes their place, but the lessons that it does not affect do not change.” Lecturers, regarding course changes also stated that since the early 2000s, courses related to computer programs, multimedia design, research for the product, user research, design methods, service design, robotics and ardinio related courses have been tried to be included in the education programs.

Studio Lessons

Project Topics

In the studio lessons, it was seen that the projects were mostly shaped according to the trends in the world and new subjects included in the design practice were reflected in the project subjects. As a result of the responses of the participants, it was revealed that the issues on the agenda in the projects were directed towards service design, interaction design, experience design, system design, designs for the social field and interdisciplinary studies. The most important factor in the change of project topics has been technology. A Generation X instructor reflects general view by saying: “Of course, the subjects of industrial design as a field of science have changed. In other words, with the introduction of information technologies into products, we started to talk more about interaction design or experience design... In the past, maybe static features were more important... Now the relationship with the product has started to include more processes... of course, the content of the project topics has changed.” From the student's perspective, another change observed by the instructors is that students are more comfortable expressing and objecting to their ideas about project topics. It was stated that Generation Y students wanted new technologies to be included in their project subjects. The view that the lecturers of Generation X and Y shape projects because they are more open and prone to new topics, has been frequently expressed by the Silent Generation and Baby Boomer. A participant of the Silent Generation states this situation: "If you have an unrealistic request due to the habits of the old generation, then the student is really do not want it and say there is not even an example of this, 'Why do we do it?' The new generation of faculty members are dealing with things that they know themselves more naturally". In addition, according to the instructors, the fact that characteristics such as perseverance, discipline and taking initiative became less visible in the transition from the Silent Generation to the Y Generation caused the scope of the projects to be limited sometime.

Project Description

The data revealed that Generation Y students expected clearer definitions compared to other generations. A Generation X lecturer said, “One thing is very clear, for example, I can definitely say that. If I'm giving an open-ended project, it doesn't work". A participant of the Baby Boomer said that the project descriptions were made clearer because of this attitude of the students and added "…We try to write as clearly as possible… I mean, student asks what you want in this project very clearly". It was another common view that this attitude of the Generation Y students led to a more methodological approach in defining each step related to the project. Generation X instructor expressed this situation as follows: “For example, they would give us a project, they would not define the steps of the project too much. You will decide what to do. Now design thinking etc. It seems like it started to go a little more methodically with concepts such as...” By addressing the intersection of design practice and the change of student profile, a Baby Boomer Generation participant said: “The World Design Organization also changed the definition and expanded it. It doesn't just say product, it says product, system, service, experience and defines it as a problem-solving process. Therefore, the project, which was given in education while it was object-oriented in the past, now a more contextual definition is introduced, or perhaps a technology is defined. Therefore, we tell the student where to do research and with whom to meet. For whom it was designed. In these respects, of course, the briefs have also changed.”

Critique Process

Feedback in studio classes is an important pedagogical tool to encourage students' progress. A Generation X instructor stated that this process was also affected by the personal qualities of the instructor and said: “I learned everything on the project. The way the person who told me everything handled the problem, his personal charisma, the sociological, cultural and objective heritage he accumulated in his own vital world became so important...” Therefore, it has been understood that different generation characteristics manifest themselves in the critique process. According to the expressions of the participants, one of these features is that students' expectations of approval for each step of the project during the critique phase increase. Particularly, the desire of Generation Y students to progress by getting approval at every step was frequently observed by the participants. Generation X participant said, “Our teachers would confuse us and leave. They do not tolerate confusion; they want to get results more quickly and they want approval...” Another generation X participant expressed follow as: “Criticism turn into a process of domination and approval… The student develops tactics that go against the nature of this job.” In addition, it has been frequently stated that the ability of students to stand behind their ideas has gradually weakened since the Silent Generation. A Generation X participant stated this attitude of the students “Of course, we were very stubborn according to them. In other words, when the lecturer said something, there would be things we objected because 'no, I do not want to do it, or that I do not think so'… Now we cannot create that station at the student…” Another change caused by the different characteristics of the generations has been the auxiliary tools used. Instructors stated that Generation Y students tried to include technological elements in the criticism process after they started to participate in education. A Generation X lecturer said: “The main change in studio lessons may be criticizing on the computer screen, not on the paper, because in the past, people used to express their ideas by drawing, since we were not too busy with computers. Since everyone can change the model quickly and return to the previous alternatives in that change, we can see the before and after, and we experience a faster process in that way.” A Generation Y instructor exemplified the involvement of technology in the process as follows: “For example, we have a portal on the internet. We critic from there. There was no such environment before…” Another issue that was mentioned by the lecturers about the criticism process was that the process was shaped depending on the subject student profile. A Generation X participant said, “For instance, the board criticism does not fit the students, so you try to make another review. In other words, I think all studios adapt themselves to the incoming student."

Design Process

The data of this study showed that the problems experienced by current students in the design process were personal, especially design thinking and abilities. It was the first opinion expressed by the instructors that they had more difficulty in managing the project process alone compared to previous generations. A Generation X participant said, “The current student has a situation like not being able to take initiative. They have less jurisdiction. Everything is given they, probably because of that…But what happens is that you cannot perceive something without touching it, so what the previous generation did is directly related to life…” In addition, it was observed that in the transition to Generation Y, it was evident that they mostly made research on the internet and wanted to reach the result with less effort, that were considered as a negative development by the academic staff. The Generation X instructor expressed this situation as follows: “20 years ago, when students were given a project, they would do research on it. They would go to the producers to do research to listen to it first-hand. The current generation has a problem like this; they take over the internet and they get what they see.” Other problems expressed by the participants and thought to be increased compared to the past are the poor use of time, the long duration of the research process, distraction, and lack of intellectual infrastructure. Regarding this subject, a Generation X lecturer said, “The process of researching and finding the subject takes too long. They cannot adapt, they cannot examine the problem. It is getting much more difficult. Time is not enough…” Another Generation X lecturer stated as follows: “At the stage of the formation of the product we call “concept” in terms of intellectual depth, major bottlenecks arise in supporting the intellectual background, maturing the process and criteria, reconciling, and drawing a sane and sustainable conclusion from this." Another common view expressed by the lecturers was that the students tended towards projects far from reality. A lecturer from Generation X said: "The share of productivity is less. It got a little lighter. Our juries are getting lighter."

Technology Impact

According to the responses of the lecturers, the most important reason for the change in studio lessons is technology and the relationship that new generations establish with technology. It is one of the common views that the tools and techniques that required manual skills were used in the past have lost its effects and because of the use of technological tools manual skills are affected negatively. This criticism, especially voiced by Silent Generation lecturers as follow: "For example, we did not have a computer in our environment, it is the most important one. The utility of the computer is of course very definite, but the whole issue begins with the pen I hold and, in the imagination." And "The most creative, original part of design is not something to do with a computer. The only thing that determines the idea is your perspective, your line...Now, this event brings two kinds of beauty, such as saving time and convenience, and one great evil. You're what the computer gives, it's a pathetic situation." The most expressed thing by the lecturers is that students' projects depend on computer facilities. It has been frequently observed by the instructors that with the digital design tools becoming dominant, students are advancing the projects they can do with these tools. A Baby Boomer participant expressed a common opinion on this subject as follows: "I definitely see that students take shelter in the easiness of giving up something that cannot be drawn in the computer program. In our time, a lot of effort would be spent. This handicraft, that is, the craft side of the work, was stronger, and those who did not do this could not be successful…" A Generation X lecturer expressed his view as follows: "The introduction of the computer created laziness and created trust to machine. It should have been a tool, it became a goal, it became a limiter..." With this approach of the students and the loss of hand drawing and other hand skills were frequently criticized by the instructors. Especially the Silent Generation and the Baby Boom Generation expressed the view that the need for students to have a drawing skill to express themselves, their designs should contain flavors that will show that are made by human hands, and technology cannot provide the qualities that the designer's infrastructure in solving problems will provide. A Baby Boom Generation instructor made the following criticism: "In the past, people were learning by doing, now they are learning by using… So, we are trying to train designers who do not have manual dexterity but leave the job to the machine with rapid prototypes and do not learn about the concepts of surface quality, behavior of materials, vein of materials. How true this is and how healthy it is evident with the results. Of course, technology is very important in design education, but it has a basis and has nothing to do with technology." In addition, there was another common opinion expressed by the instructors that, with the start of computer programs to give satisfactory results, the need for mock-ups and models by student in the design process began to decrease. A Generation X instructor expressed the general view of instructors as follows; "While there were students who made models by hand 15 years ago, they no longer want to make models. Now they do not see this as an education and learning process." In addition to these criticisms, it has been observed that some Generation X instructors have a more positive attitude to the use of such tools as they accelerate the processes. For example, a Generation X instructor said that; "Things like three-dimensional modeling, they brought a lot. They can see more clearly if something is going to happen." A Baby Boomer Generation instructor expressed his opinion on this subject, contrasting his generation, as follows: “Instead of making a mock-up with cardboard, if even the student has these tools, it doesn't bother me at all that he should do with these tools. On the contrary, I think it's good for them to try different things. If it cannot easy, maybe they will never try it, maybe the design will not develop on that side. I think all these are very useful...” In addition, it is another common view for Generation Y students who technology is a part of their lives, do not accept and make sense of any approach other than using these technologies in the design process. A Baby Boomer Generation instructor said, “The students feel that they can now do their presentation with the professionalism they see outside, and therefore they want to separate themself from traditional technologies as much as possible. Therefore, it is not possible to say that this request of theirs is artificial.”

Jury Process

The statements of the lecturers have revealed that the behaviors revealed in the juries differ according to the characteristics of the different generations of students and faculty members. Especially for Generation Y students, it was understood that respect for authority, attitudes towards criticism and their ability to express their thoughts supported this change as distinct characteristics. Accordingly, it is one of the shared common views that this generation is more closed to criticism than the other generations, that they express their opinions freely without accepting any authority, and that they question the evaluation criteria. One of the instructors of the Baby Boomer added that this situation also affected their own attitudes and said, “In the last 5-10 years, we could not to break that attitude of the students. This education is a discipline based on criticism and trial and error. However, the students are so closed to criticism...They perceive it as a personal thing, they approach all kinds of criticism very emotionally, and reactively. We have become unable to criticize the work done comfortably as we used to do. They are raised spoiled; they have high egos. So, when you criticize his work, you overthink. I wonder, how much it will hurt they, will I disincline emotionally they, what do I need to do to win they...” While talking about their student period, Generation X instructors stated that they were exposed to a harsher attitude by their professors and that the behavior of instructors in juries changed in line with the changing student profile. A Generation X also stated that the students' perspective of the jury changed, the juries became a process where students focused on the note instead of seeing their shortcomings, and that affected the communication of the academic staff with the student and said, “The perspective to the judges has changed. For example, one of my students said please do not criticize at our graduation jury the other day…Unfortunately, one of our lecturers said that 'you failed to that one of things of that model'. He/She said, 'please don't say that'. Because he/she sees it as a note tool. However, the juries are a place for discussion…Actually, the student is not aware of it, this affects the relationship of student and lecturer."

Studio Culture

The Silent Generation, Baby Boomer and Generation X lecturers have stated that studio courses not only founded the base of the education system but also created a specific culture as a social interaction environment as. They think that working with their friends and adopting that place creates a corporate belonging and affects their projects. When they compared their student periods, they indicated that there was no such case for Generation Y students, and they observed that this situation was parallel to the individual attitudes of the individual students. A Generation X instructor expressed students' attitudes as follows: "There is nothing like a studio culture in the new generation, they do not have a working together culture...They are not tempted to work together, and they are too individual which creates a problem. Therefore, they do not like working in the studio either…I can say that we were not like that. There is a huge difference compared to 10 years ago…" On the other hand, the decrease of the concentration duration and the request of working independent of a specific environment show parallel results with the participants' opinions. A Baby Boomer lecturer provided the following example about this situation: "…I cannot carry on the working habits in the same class as I used to in the past since the concentration duration decreased. I can't go over a table and work for a long time with a pencil and a paper."

Relation Between Student and Lecturer

When the statements of the instructors are taken into consideration, it has been understood that how the instructor shares the tacit knowledge which an instructor conveys by combining his background knowledge, basic education skills and principles, with the student is very important for design education. In general, there has been a common opinion on the increased student-lecturer interaction compared to the previous generations. When Generation X instructors compared their studentship periods, they expressed that currently the attitude towards the students have been softer, while there was a tougher structure against the students in the past. Particularly for Generation X and Y, the instructors stated that they have more duty in developing the student-lecturer relations and they put more effort to understand the students compared to their studentship periods. A Generation X lecturer explained this effort as "…We are trying to talk not only as a project but also in general. So, if he/she cannot succeed in something, you are trying to understand him, for instance if there is something about the family and so on… Now we have become a little more accessible by doing so." The fact that social networks increase and differentiate student-lecturer interaction is another common opinion of most lecturers. A Generation X instructor expressed this situation with the following statements: "When I check a colleague's Facebook page, I see that more than 50 of his students follow… The flow of information, the announcement of the exam dates, the school trips etc. It has much more advantages over classical announcement pane leading to deterioration of relations. In the project development process, regardless of the working time or the lecture limit of the project, it has many benefits to support student's development when his/her effort has been seen. It is impossible to deny that there is a more socialized and fluid relationship level." In addition, depending on the conflict between the generations, there is a common idea that the old generations criticize the young generations and the young generations do not like the old generations.

Conclusion

While the oldest generation who studied in Industrial Design Departments in Turkey is the Silent Generation, existing generations consist of Generation Z who are relatively new to higher education and Generation Y. In this study, the changes in industrial design education since the studentship of the Silent Generation were examined. In-depth interviews revealed the values, attitudes, and thoughts of different generation individuals towards design education. The data obtained showed that changes arising from generational differences generally occur in the student profile, learning characteristics, education system and curriculum, studio courses and student-instructor relationship.

Generational differences in education were most evident in the students' changing characteristics and different perspectives arising from their involvement with technology. One of the clearest conclusions reached within the scope of the study is that the generation identities of different generations of students in industrial design education are significant and distinct. According to the data obtained from the study, most of the characteristics of the generations are in line with the literature, whereas the Generation Y is described as individuals who accept authority and obey the rules in the literature contrary to the obtained data (Howe & Strauss, 2000; Gursoy et al., 2008). On the other hand, Generation X and Baby Boomers, who are stated to question the authority in the literature, have been described as individuals submissive to authority in this study. However, in education, it has been observed that different attitudes about respect to authority are discussed in terms of the students' acceptance or questioning levels of traditional views and orders. In addition, it was revealed that Generation Y students were not prone to group work, unlike the literature, depending on their individual attitudes. The changing characteristics of the students resulted in both the differentiation of educational approaches and the adaptation of communication with students accordingly. It can be said that a more student-centered and more declared process included educational approach has begun to be adopted by Generation Z students.

Within the scope of the study, it has been revealed that the biggest factor that makes a difference between individuals from different generations is technology and the involvements of generations in technology. In parallel with the literature, it was found that the involvements of the Generation Y and Generation X students in technology was more intense and better than the Silent Generation and Baby Boomers. Considering the effect of technology, it has been observed that with the inclusion of technology in the process in accordance with the generation literature, the concentration time of the students in the transition to the Generation Y has been shortened and the multitasking habits have increased, and it has been revealed that the close relationship of Generation Y with technology is effective in this case. It has been revealed that technology also changes the tools used by students and learning environments of them and thus students prefer an independent learning style. In compliance with the generational literature, the desire of Generation Y students to include technology in every stage of education has been criticized by the Silent Generation who are relatively distant from technology and approach cautiously. The X Generation instructors, who are better with technology, approached more positively. Baby Boomers, who have a more indifferent and harsher attitude towards technology, do not take a conservative attitude towards the use of technology by the students as long as it is used correctly. That fact shows that the obtained data conflicts with generation theories.

It has been observed that this process tried to be made more methodological when the approaches of the Silent Generation instructors who rely on the standardized procedures and templates with their commitment to the control-command leadership (Martin & Tulgan, 2006) and Baby Boomer instructors who respect authority and hierarchy (Gursoy et al., 2008), combined with the characteristics of the Y Generation students. It has been observed frequently that Generation Y students avoid taking initiative, want to move forward with approval, their ability to stand behind their ideas has weakened, and they are result-oriented compared to previous generations. In line with the literature, the reason of that fact is, helicopter parents making decisions for them and planning their lives. Besides, these attitudes of new generation, who want immediate results-oriented feedback and approval, have also been parallel to the generation literature. Interaction and communication emerged as another problem especially in the decision-making process and the study revealed that students rely on instructors and the internet to solve learning problems.

Considering the characteristics of Generation Y which make up the majority of the last generation of students and Generation Z, which make up the majority of the current generation of students, the inclusion of the latest technologies, which have an important role for these generations, will strengthen the sense of responsibility of students, improve their decision-making skills and improve their creativity in wider areas. It can be said that it would be appropriate to carry out the activities that they can use. In addition, it is considered important to provide clear definitions of projects and processes and to make clear expectations. It is claimed that the use of visual elements in education is more beneficial due to the cognitive development of Generation Z (Rothman, 2014). In addition, it is argued that students should be given the opportunity to use the skills they are aware of and that motivates students to do so (Prensky, 2014). The development of support for communication and interaction with students, the provision of frequent and immediate feedback, the use of online course materials, the incorporation of learning materials with more visual elements into the process, the presentation of projects that interest them and can relate to real life, and the creation of an understanding of research-based education for Generation Z students are required education strategies. Hence it is important to create an open educational structure that can support a dynamic approach in both the design practice and the student profile and adapt to rapidly changing content. To ensure that education is appropriate and effective, the ability of control to students learning processes should be supported by a student-centered learning environment.

This study was carried out within the scope of industrial design departments in Turkey. Therefore, even if the concept of global generation is mentioned today, the study should be evaluated in the context of Turkey's local conditions. Industrial Design Departments of Turkey due to the great majority of the human resources Generation X, and mainly consisting of the participants of Generation X lecturers, are limitation in this work. In addition, since most of the last generation of students are Generation Y, the views of educators focused on Generation Y. In addition, it should be stated that the results obtained in the study are limited to the views of the academic staff participating in the study and that the differences arising from the educational approaches of different universities are excluded from the scope of the study. On the other hand, another limitation of the study is that it is based on cross-sectional data, due to the uncertainty of the differences between generational characteristics and individuals' age-related characteristics. It would be appropriate for future research to consider the characteristics of the participants longitudinally.

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Book Review

Teacher as Designer: Design thinking for educational change

Scott, D. & Lock, J. (Eds.). (2021). *Teacher as Designer: Design thinking for educational chang*e. Springer. DOI 10.1007/978-981-15-9789-3

Reviewed by Daniela Schillaci Rowland, Presdales School, UK and Alison Hardy, Nottingham Trent University, UK

Introduction

Practitioners are the intended readers of 'Teachers as Designers', serving 'as a guide to practitioners that links theory and practice with regards to design-based processes in education'. The two editors, David Scott and Jennifer Lock from the University of Calgary in Canada, have curated contributions from Canadian academics and classroom and school-based practitioner, however they do refer to theory and practice outside Canada.

The book is divided into three sections: *differing perspectives on educational design*, *key actors within educational design* and *new possibilities for design in education*. The first section examines design processes in education, the second presents how teachers, leaders and pupils can be involved in educational design, the final one focuses on design within maker and making contexts. Although the final section appears to be of main interest to those involved in design and technology education, we think there are chapters in the other two sections that are also of interest.

Each chapter follows a similar structure: brief abstract, keywords, guiding questions and is bookended with a vignette of a teacher rethinking an established curriculum activity. The guiding questions are meant to help any reader gain the most from the chapter, however some are too narrow in their focus.

We, the reviewers, work within design and technology education; one at an English secondary school, the other a UK university. We found there was something for both of us in the book's chapters and reviewed the chapters we thought related most to our interests and contexts. Daniela reviewed chapters 2-4, 8 and 9 and Alison looked at chapters 1, 5, 6, 7 and 10.

Chapter 1. Considering the Human in Human-Centred Design by Sandra Beck

This chapter's vignette describes a teacher who wants to move from a superficial outcomes-based learning activity towards one that takes a human-centred design (HCD) approach. First, the author provides a brief and limited history of HCD. Next, she argues that a technical stance often leads to superficial solutions that rarely consider stakeholders, whereas a designerly approach views problems as 'multi-faceted and complex' (p.12) giving more freedom to take risks. To help teachers manage these risks, the author presents 3 models of design that could be used in education: the Double Diamond, the d.school at Stanford University's 'Design Thinking Bootleg' and Cooper Hewitt, Smithsonian Design Museum's K-12 Design in the Classroom. This chapter provide a good introduction to the rest of the book, but readers experienced and comfortable with taking a designerly approach may find it too simplistic.

Chapter 2. Reframing Inquiry in Education: Designing for a Living Curriculum by David Scott and Deirdre Bailey

The foremost intention of this chapter is to shift the mindset that inquiry-based learning is confusing and too open. To do this, Scott and Bailey use several points of research and pupils as co-architects. They explore inquiry based learning using the Double Diamond model (2019), despite some resistance from policy makers. What draws you to this chapter is the introduction-a keen, enthusiastic teacher who finds himself questioning his own practice, a common theme for some early career teachers. Excellent teacher preparation, alongside student's assistance in driving authentic forms of inquiry. It does come with a warning; that 'it should be noted that designing for rich inquiries is a deeply iterative and recursive process.' Rich inquiry is needed, but how it is structured is where change can materialise. This chapter highlights issues surrounding education policy; sometimes even the best concepts face barriers outside their control, but with careful preparation and planning in your individual setting, Scott and Bailey believe it can lead to authentic design inquiry experiences for students.

Chapter 3. Designing Learning Through Universal Design for Learning by Evelyn Hickey

This chapter focuses on how taking a universal design approach it is possible to design learning approaches to reduce students' barriers to learning, thereby creating a more inclusive environment. It begins with a discussion about Universal Design for Learning (UDL) that includes three principles: engagement, representation and expression. Each of these are described in turn and a helpful list of questions is provided for teachers to use with planning. Later in the chapter, Hickey shows how a lesson can be designed through the lens of UDL. The arguments presented are persuasive and would be useful for beginning teachers to read.

Chapter 4. Teacher as Designer of Learning; Possibilities and Praxis of Deep Design by Stephanie Bartlett

Collaboration and trust are two keywords for this chapter. This is by no means a 'does exactly what it says on the packet' guide; however, the fundamental characteristics are basic and will lead students to develop skills that will help them when stamina is needed for longer blocks of learning. Bartlett states that using dialogic pedagogy will help to promote asking those high-order, open-ended questions that lead to deeper levels of engagement and learning. To be able to achieve this however, the teacher needs to have a repertoire of skills to help scaffold the activities. The discussion about what disposition for design in education is, and how it can be used by educators to think about their own practice, is heavily supported with some excellent research. The chapter then leads to how the principles might be applied-it is about building relationships and confidence in pupils to ensure they feel comfortable to take risks-this is where the magic of learning takes place. What finishes the chapter off nicely is the exploration of surface design challenges versus deep design; it is the surface design challenges that build the skills, whilst deep design can only occur once collaboration and trust have been developed through short, focused design tasks.

Chapter 5. Students as Designers by Erin Quinn

Students having fun and being enthusiastic in a lesson, does not always mean that students are learning key concepts, as discovered by the author of this chapter. This chapter addresses this issue by seeking to empower students and to become co-creators of their own curriculum. With the focus on innovation, critical thinking, problem solving and communication, the hope is that it will lead to collaboration amongst the students, where these skills can be used to establish deep design thinking. Quinn champions the need to build confidence in pupils so that they become change-makers. The example of how the pupils at the Riverside School in India help to solve issues locally, and in collaboration with different communities, provides a good example of how teachers who provide a non-failure environment, and develop design thinking in their pupils, can lead to real change.

Chapter 6. A Voice of the In-Between: Design Thinking and Heart-Centred Leadership by Ankush Garg and Katherine Culhane

This chapter is a case study about how design thinking principles can be 'infused' into educational leadership practices. The authors describe their experiences as curriculum leaders responding to policy and curriculum changes in western Canada using 'heart-centred leadership' (p.85). Heart-centred leadership is described as a style where 'leaders seek to bridge multiple stories, perspectives and needs of the community through collective decisions and actions' (p.91). This complexity and ensuing tensions of managing ‘wicked’ problems affected by policy shifts, changes to curriculum and other government agendas, will be familiar to most educators regardless of location. The authors explain how they took a design-thinking approach to design 'a human-centred educational system' (p.91); their approach had three principles: inspiration through empathy, ideation through radical collaboration and enactment through iteration. Although this chapter may not be directly relevant to all D&T educators, it does serve as example of how design language and activities are being adopted beyond the design classroom.

Chapter 7. Design Thinking Through Passion-Based Learning Janette Hughes and Laura Morrison

The authors define passion as a driver or evidence of students' engagement, excitement and progress; they see a student-directed approach as being 'passion-based'. The chapter reports on a study undertaken by the authors of a 'week-long passion project guided by the design thinking process' (p. 104) with a group of 15 children aged between 7 and 14. The premise was that for students to engage in the project with passion the focus had to be something the students cared about. What the authors describe is recognisable as an open-ended design project, where students have agency to make design decisions about their work and what they need to know. This chapter's strength lies in the honest and recording of the project's aims and process, plus the challenges and useful suggestions. The authors provide a useful case study of a student-led, open-ended design project that would be useful for beginning teachers to discuss, and experienced ones to reflect on and critique; the five principles of design at the end of the chapter are a helpful discussion and reflective framework.

Chapter 8. Re-imagining Assessment: Assessing Design Thinking Within Makerspaces by Sandra Becker and Jennifer Lock

In this chapter, Becker and Lock state that identifying and assessing transversal (transferable) skills can be difficult to do within the realms of makerspaces. Giving students the opportunity to explore, tinker and discover different materials and products can lead to many lines of inquiry, which pupils then begin to research and answer. Becker and Lock draw on the use of the Makerspace Assessment Framework (2018), and designerly thinking. In order to assess the design stage, teachers need to be flexible in their approach to assessment. The example given, in the form of a table, is a great way for educators to begin that internal dialogue about what and how to assess. Teachers need to draw and reflect on many different viewpoints and exploring different avenues of assessment; a comprehensive list is also included in point five. The 'principles of design' at the end of the chapter provide a clear and concise starting point. Flexibility, good background research and considering different stances is ultimately what make this study a success.

Chapter 9. Design Principles for Teaching Sustainability Within Makerspaces by Paula MacDowell

The opening vignette paints a picture that connects the reader to this chapter; curiosity of design, as a child is one that many can relate to, though thinking about the life-cycle of the products possibly did not feature. Sustainability is a key factor across as aspects of design, so it can be difficult to teach students to put this at the forefront of their thinking when using makerspaces to explore avenues of design thinking. This chapter serves to guide students in using their own integrity and values to encourage others to consider sustainability in their own learning. Petrina's (2000) ideas about sustainability are used to challenge teachers to re-evaluate prioritising sustainability when considering how to teach students about the use of makerspaces and design development. The result of the research led to Tech for Change Makeathon 2017, where students produced digital technology to help people consider how they can have a more positive and sustainable impact on the world.

Chapter 10. The Future of Design Thinking in Education: Challenges and Possibilities Jennifer Lock and David Scott

Editors Jennifer Lock and David Scott close the book with a summation of the challenges and possibilities of using design thinking in education. The concluding chapter reminds readers that the chapters are based on examples of experience, they are not there as a template to follow which would contradict the book's notion of the teacher as designer.

The editors acknowledge the challenges of shifting towards using a design process to improve education, such as resisting current trends in a 'back to basics vision of education' (p.152). To do this, they argue, educators and teachers need to 'think like a designer' - this book is a useful starting point for those unfamiliar with this approach and provides some useful insights and reminders for those more familiar with taking a designerly approach.

Book Review

Food Education and Food Technology in School Curricula: International Perspectives

Rutland, M. & Turner, A. (Eds.) (2020). *Food Education and Food Technology in School Curricula International Perspectives.* Springer.

Reviewed by Julie Messenger, Independent Consultant

Introduction

This publication is part of a series of books that look at contemporary Issues in Technology Education. It describes up to date research concerning food education and food technology in an easily accessible format.

International and UK contributors from a variety of backgrounds and contexts, provide a diversity of perspectives on food education both teaching and learning in differing contexts. e.g., primary, secondary, and vocational school education, undergraduate initial teacher education programs, and in-service professional development. Consequentially it presents a variety of teaching, learning and curriculum design approaches relating to food. It offers an insight into some of the diverse issues in food education internationally, lessons to be learned from successes and failure and includes some action points to address issues highlighted in the chapter.

The book was composed for researchers, teacher trainers, trainees', curriculum developers, CPD providers, and teachers in primary and secondary schools.

Structure of the book

The book is carefully structured to make it easy to access the knowledge, experiences and perceptions presented by the valued contributors whose biographies are included in the publication. The structure enables researchers to access the information they require without wasting time reading articles that are of no relevance.

A well written forward, stressing the importance of food education by Stephanie Valentine sets scene for the book. (Former/Retired Deputy Director General of the British Nutrition Foundation). The forward outlines the history, the importance of food education to the health of our nation, as well as the opportunities for careers such as Nutritionist, Dietitian. Stephanie mentions the need for a high-quality food education, delivered by trained and experienced food teachers in all contexts.

Stephanie ends with this comment about the book.

> *'There is much for teacher educators, providers of in-service professional development, and external examination developers to reflect upon and some inspirational new ideas to*

"share." Reflection is a valuable learning experience, whereas complacency is not. So, where should we be heading in the next few decades? Clearly one size does not fit all. Thought provoking!'

Following the forward, are the biographies of the contributors. The contributors are knowledgeable authors involved in higher education or teachers working at the chalk face in schools in the UK as well as other countries. This background information creates confidence in the authors contributions.

The book is divided into three parts:

- Part 1: Food Teaching in Primary and Secondary Schools in Different Cultures.
- Part 2. The Professional Identity of Food Teachers
- Part 3. Current Content and Contemporary Issues

Every section of the book is made up of chapters. Chapters are all presented with an abstract, key words and a conclusion. There are copious references after each chapter allowing researchers to follow up topics that interest them. Data from relevant research is presented in a format that allows the reader to see where the knowledge and conclusions have come from. Some data is experiential and anecdotal. However much of the data has been collected from primary research techniques. The relevant data has been well-presented using appropriate methods e.g., charts, and diagrams This format makes chapters effortlessly available to all users.

The introduction, chapter 1, is written by Marion Rutland and Angela Turner. It outlines the content of each chapter within each part of the book. This information allows the reader to focus on the chapter(s) that are relevant to their needs. In addition, there is a summary of each chapter at the end of the book. A useful summary of the key points that have been raised throughout the publication can be found at the end of the book

Part 1: Food Teaching in Primary and Secondary Schools in Different Cultures

This section comprises of seven chapters which explore a range of curriculum approaches in primary and secondary food education in England, Ireland New Zealand, Australia, and Malta. Some continents are not represented e.g., America, Asia. The international articles have been written by contacts of the authors.

Chapter 2 Exploring Food education in the English Primary Curriculum by Sue Miles-Pearson

This chapter looks at the developments that have occurred in food education in primary schools from 2009 -2018. Due to the demands on the curriculum time of literacy and numeracy the chapter highlights that food education has changed from teaching basic practical food skills to extracurricular activities such as after school clubs and growing fruit and veg in school.

Considerable primary research is recorded in the form of tables which provides clear evidence of what is being taught currently in primary schools in England

Chapter 3 Reducing Challenging Behaviour and Maintaining Aboriginal and Torres Strait Islander (ATSI) and Non-ATSI Student Retention Through Food and Exercise in Primary and Secondary Schools in New South Wales, Australia by Gillian Stuart and Angela Turner

This chapter reflects on the personal experiences of the author. The research projects and initiatives that she was involved in.   It includes looking at aboriginal and non aboriginal cultures and cross-cultural teaching and learning contexts in primary schools in New South Wales, Australia

The chapter is exemplified with images and diagrams. It illustrates an interpretation of food education which reflects cultural influences, and argues that 'enriched learning environment supported through physical activities and food applications are the most salient influences on intellectual learning outcomes '. Finally, the impact of these projects having a lasting impact 'well beyond the school gate'.

Chapter 4 What Is the Current State of Play for Food Education in English Secondary Schools? by Ruth Seabrook and Vanessa Grafham

The evidence for this chapter has been collated from case studies from a range of Food teachers in English secondary schools. The chapter discusses the unprecedented changes to the national curriculum for design and technology and food technology. However, whilst there are many students aged between 14-16 years studying food. It is disappointing that the subject lost the 16-18 years examination which provided progression into higher education. This situation is seen by the author to be 'a major issue that needs addressing'.

Chapter 5: A Technological Approach to Secondary Food Education in New Zealand by Wendy Slatter

The chapter examines secondary food education in New Zealand. Food education is delivered via two areas of the curriculum., 'The Health and Physical Education Curriculum' and 'Technology Curriculum'. Food education is not just about teaching cooking skills but considers the links to health and fitness. The chapter offers thoughts about where food is or should be positioned in the curriculum. It defines some new terms 'technological food literate' and food literate. The chapter offers a well-balanced argument as to which curriculum area food education is best placed.

An academic chapter on what food components can be taught to 12-14 years old students in New Zealand. There are several diagrams which consider the content of the different interpretations of food education.

Chapter 6: Developments in Secondary Food Education in England Since the 1970s: A Personal Perspective by Angela J. Turner

An historical account of Angela's Turners perspective on food education. She takes us through the developments of food education from the 1970's to the present day in the UK. Angela sees that food is naturally part of our culture. She states that food should be 'high profile and valued for its contributions to a healthy society' she asks if we 'still have issues to address in secondary schools in England'. She describes her interpretation of what a good food education will look like. and provides very useful information for curriculum developers to consider.

Chapter 7: Food and Nutrition Education in Malta: A Journey Across Time and Subject Boundaries by Suzanne Piscopo

Here current food education in Malta is described in detail. Malta has a home economics approach to food education. Suzanne sees future development in food education revolving around the Mediterranean diet. She sees 'the goal is the enhancement of wellbeing and quality of life of Maltese food consumers and producers'.

Chapter 8: Home Economics Education in Secondary School Settings: Lessons from Education Policy on the Island of Ireland by Amanda McCloat and Martin Caraher

A comparative case study approach is used in this chapter. Food education (Home Economics) is a compulsory subject in Northern Ireland. With policy to have food education compulsory in The Republic of Ireland. Home Economics in the Island of Ireland is 'A holistic, multifaceted and comprehensive food education …. aiming 'to develop a sustainable healthy approach to, and relationship with food'. Scientific theory and its relationship to practical food preparation delivers a positive relationship with food.

The chapter looks at the teaching and learning approaches to Home Economics in both Northern Ireland and The Republic of Ireland. It highlights the similarities and the differences in the pedagogy between the two countries. The content of Home Economics in both countries covers practical skills, and the applications of scientific and theoretical knowledge, which is delivered in an experiential sequential and integrated approach developing a positive relationship with food. Plenty of research has been referenced and makes for an informative chapter.

Part 2. The Professional Identity of Food Teachers

This part will look at the influences in schools, higher education, initial teacher education, continuing professional development (CPD) and vocational programmes on the identity of food teachers in different countries, contexts, and cultures. Many of these six chapters relate to food education in Australia

Chapter 9: Positive Ingredients to Redefine Food Education in Schools in New South Wales, Australia by Donna Owen

This chapter looks at the idea that food education in Australia is taught according to the teachers interprets the curriculum. It reflects on the same content being delivered generation after generation. Donna accepts there are critical life skills that need to be taught, but she states that students need to be exposed to current issues and problems relating to food security and sustainability.

Twenty food teachers were surveyed to see what key factors influenced the development of food education. The result being that teachers need to be flexible and open to curriculum changes, they need to develop their own professional knowledge through professional learning.

Teachers' personal development should be reflected in the curriculum delivered, ensuring that food education is both current and relevant, equipping students to take employment in the food industries. A chapter that uses primary research to develop a reflective review on the food curriculum in Australia.

Chapter 10: Where Will Future Secondary Food Teachers Come from in England? by Sue Woods-Griffiths and Suzanne Lawson

Sue and Suzanne talk about the status of food education in schools. They state that food lacks academic credibility. This is an issue as food education doesn't meet the needs of the food industry. The consequences of the removal of the 'A' level means there are few routes to university degree courses. The status of food in English schools is described in a clear way.

Chapter 11: Changing the Professional Identity of Food Technology Teachers in New South Wales, Australia by Deborah Trevallion

This chapter reflects on many case studies about people in New South Wales who select a second career in teaching food and apply to complete an Initial Teacher Education Degree. They come to the degree with a wide variety of life experiences and skills and values that are associated with their previous employment.

Many trainees tussle with learning knowledge relevant to teaching. They struggle with establishing their identity as a food teacher. The chapter explains how important it is that universities take on board the tensions and resistance of trainees to the changes in the field of education. Universities need to develop a willingness and an acceptance to promote the new curriculum and ways to deliver it throughout the coursework. Several diagrams and chart help to support the point raised with in the chapter. The chapter reflects on the new developments in the food technology curriculum and the changes that potential food teachers must follow to keep the subject up to date.

A complex set of issues are presented here with extensive relevant references.

Chapter 12: Qualifications for Working in the Food Industry: Understanding All the Available Options for Students and Educators in Victoria, Australia by Bronwyn Graham

Food education in secondary schools in Victoria, Australia has in recently undergone change. The role of the food technology teacher is explored. The content of the of the food syllabus and how it is taught is studied. With many opportunities to gain employment in the food industries in Australia, this chapter explores the many routes to careers within food industries. It recognises that the food teacher is the person students turn to for advice of a future career path that involves food.

The chapter contains detailed information on the qualifications that are on offer in Victoria. It presents detailed and specific information on qualifications that are available. It uncovers the wide variety of routes/ qualification to get access to employment in the food industries. This information would be helpful to policy makers. References are mostly from online sources.

Chapter 13: Continuing Professional Development for Secondary Food Technology Teachers in New South Wales (NSW), Australia by Carly Saunders

> *'The New South Wales Education Standards Authority (NESA) mandated that all teachers must accrue professional development hours to maintain teacher accreditation. NESA Registered Professional Development can only be delivered by Endorsed Providers who have completed a rigorous assessment and approval process.' (p. 196)*

Two hundred and forty one Australian teachers took part in a qualitative research survey that looked at what professional development courses would help teachers to keep up to date and teach food technology to learners of the future. 'The practical, hands-on, recipe testing, cooking on a budget, cooking to an hour time' courses received the most votes.

There are references to applicable organisations and articles, which help to substantiate the information presented. There are several quotes from the survey responses, which provides evidence to endorse the research. The findings from the research survey discloses information which could be of value to curriculum developers and trainers in other nations.

Chapter 14: Food Education in Upper Secondary English Schools: Progression into Food-Related Undergraduate Courses in Higher Education by Marion Rutland

Initially the chapter outlines in detail the historical development of food education in the UK. There are many references to government documents which helps to confirm the trustworthiness of the information presented.

In 2013 Food was retained within the Design and Technology curriculum, considering food to be a material area. 'ingredients' being the material area. A separate section 'Cooking and Nutrition' was produced, where students were to learn to cook as it was a 'life skill'. In 2014 the GCSE Food Preparation and Nutrition was born and the new A level in Food Technology course was dropped. It was assumed that GCSE Food Prep and Nutrition would suit hospitality and catering route to employment but there was no consideration to the more academic areas of employment such as Dietician Nutritionist.

Statistics from the Food and Drink Federation, employing 400,000 people illustrate need for food teaching to cover all aspects of food, i.e. food science and technology social, political, and economic issues to provide a route into food related employment. The question posed was whether the current Food Preparation and Nutrition GCSE provides progression to food industry and food related undergraduate course in higher education. The informative chart included in the chapter, stresses that the only university that refers to food technology A level for admission requirements for an undergraduate food related degree is Leeds University

A well written chapter supported with endorsed research that highlights the need to reinstate the A level in food education to provide a suitable progression on to the more academic route of employment such as dieticians and nutritionists.

Part 3. Current Content and Contemporary Issues.

This part of six chapters explores current curriculum approaches to food education i.e., teaching of practical food skills, food technology, nutrition and health and global food supplies, in the United Kingdom, New Zealand, and ethnic cultures in South Africa and Australia.

Chapter 15: Current Research in Nutrition in the School Curriculum in England by Sue Reeves

In England Food and nutrition are delivered in several curriculum areas. Young children should be taught about food and nutrition at a young age. New research on gut microbiome in health and disease as well as global food security should be included in the food curriculum. This information will provide students with the knowledge and understanding to make informed choice about the food they eat.

> *'Public health nutrition has never been more important, with increases in the rates of obesity, cardiovascular disease, and diabetes. Nutrition and food education can help contribute to public health policies for tackling diet-related disease'.* (p. 235)
>
> *'Nutrition is a scientific subject, and rigorous methods are used for research investigations in this area. It could be argued that nutrition is a relatively new science'. (*p. 234)

The chapter uses an objective and impartial tone and examines copious references that endorse the need to include nutritional knowledge and current research within a food curriculum.

Chapter 16 A Curriculum Developer's Perspective on the Place of Food in the Secondary School in England by David Barlex

The author looks at the importance of food education from the perspective of the government, who consider the impact on the nation's health, obesity.

The elements of the chapter, The Importance of Food Education, Other Approaches to Health Eating, Teaching Young People to Cook and Eat Well, The Role of Science Understanding in Learning How to Cook and Eat Well, and The Possible Content of Food Technology Courses are logically linked and identified with headings.

The concise, straightforward language used in the chapter presents many questions which implores the readers to review and reflect the points raised by the author. A chapter that spotlights issues that the future curriculum developers should be aware of.

References confirming the source of the knowledge and understanding are within the chapter.

Chapter 17: Population Growth and Global Food Supplies by Christopher Ritson

Christopher conveys that there is considerable evidence suggesting that higher food prices has developed from the in balance of food supplies and global demand. The Reverend Thomas Malthus a political economist from the 19th Century thought that food supplies would not grow at the same rate as the population. Consequently, there would be deficit in global food supply. In principle the supply and demand of food can be reversible with changes in the patterns of eating, less meat, and less waste, combined with technological developments which will increase the supply of food. The issues raised here about sustainable consumption of food will provide a wealth of information on which to discuss and debate the sustainability of food production and consumption.

The reference list is short containing publications from the 19th century as well as recent publications from the 21st Century. The chapter raises issues that we need to be aware of when considering the content of future food technology /education globally in the 21st Century.

Chapter 18: Socially Acute Questions: How Biotechnology Can Provide Context and Content for Discussion in Food Technology Education by Bev France

Socially Acute Questions (SAQ's) surrounding Biotechnology or biologically engineering - genetically modified food are raised throughout this chapter. The pedagogy around the risks of consuming genetically modified foods, are considered.

The history around bio engineered food, initially developed to relieve the world hunger issues. It is coherently structured through the chronological developments of genetically modified foods to the ethical discussions that need to be included in food education. The chapter consider the risks connect to human health of these foods and advocates that discussion is needed so consumers make informed decisions on the food they consumer.

The chapter is clearly written and presented with exemplars throughout enabling the reader to understand key information and the issues surrounding genetically produced foods. A great source of secure information relating to biogenetically produced foods. An Interesting chapter that discusses ways to teach students both the advantages and disadvantages of bio genetically processed foods.

Chapter 19: Teaching Food Technology in a Secondary Technology Education Classroom: Exploring Ideas in Indigenous Contexts by Mishack T. Gumbo

The chapter references Sub -Saharan Africa and states there is much knowledge about the properties of plants, handed down from the elders to the younger generations. Health protecting and health promoting compounds are held in local plants which are used in the production of foods. It looks at the natural ways that native people preserve and prepare foods which are central to their culture. These natural or low technological ways to harvest and process and consume foods present a less threat to the human body with reference to 'disease and conditions such as 'diabetes, hypertension, cholesterol and obesity'. Native people have a lot of knowledge to teach the more industrialised countries and that this is an area that should be included in food technology education. The suggestion is that, in the future low tech food preservation techniques need to be combined with high tech food preservation i.e. a dual method to preserve food.

A superb chapter for discussion about the links between food harvesting processing and consuming and the health of a nation. There is an excellent chart of the natural ways that foods are process in other countries.

A comprehensive set of references which lists pages from books as well as from an unpublished dissertation, provides evidence on the validity of the content. A curious and thought-provoking chapter on the content of future food education curriculums.

Chapter 20 Learning Cultural, Ecological and Food Literacies Through the Gumbaynggirr Pathway of Knowledge Project by Angela Turner

The primary school in question is situated in Gumbaynggirr 'on the land of the people of the Gumbaynggirr nation and positioned on the last five acres of natural habitat in the immediate locality that contains much valuable flora and fauna habitat'.

The head teacher at the primary school liaised with Southern Cross University to work through a project whereby the aboriginal culture the knowledge i.e., of the locality native plants cooking methods and recipes are introduced to five teachers in one a primary school. Over 10 weeks teachers were taught by aboriginal elders about the aboriginal culture. A questionnaire collected responses from the 5 teachers who are at differing stages of their careers. The results: - 'teachers came to recognise the significance and pride in developing connections with local Aboriginal people and knowledge and how this can inform their teaching'.

A well referenced chapter which suggests that native cultures should be included into food technology/ education in the future. The chapter provides limited evidence to support this suggestion.

Chapter 21 A Synoptic view of sections 1.2.&3 by Marion Rutland and Angela Turner

Chapter 21 gives a summary of the book chapter by chapter. There is some repetition from the introduction chapter. However, it is a very helpful addition to the book as it contains a summary of the points raised throughout the book. This information is presented as bullet points making it easy for the readers to focus on the key points raised throughout the book. Researchers can backtrack and find the chapter(s) which pose the key issues raised. Many of these key issues, in my opinion, are very relevant.

My Observations

The book is claiming to be useful to,

> *"teachers in post, teacher trainers, pre-service teachers, curriculum developers, Continuing Professional Development (CPD) providers, educational researchers and educational policy makers" (p. 1).*

However the book's specialist content and the price, makes the publication, in my opinion one that will be largely purchased by higher education establishments and keen researchers. Researchers wanting to explore food education in its many interpretations across some international countries as well as the UK, will find this book a very sound, and a very reliable source of information. A unique selling point is that chapters can be purchased online direct from the publisher, so researchers or interested readers need only to purchase chapters that are relevant to their research/ interests.

Many of the key summary points need to be accessible to educational policy makers.

> *"Reading is important, because if you can read, you can learn anything about everything and everything about anything." (*Tomie dePaola)

This book supports learning everything about anything about the many issues around food education in the UK, New Zealand, Australia, and South Africa, from the past to the future.

References

dePaola, T., https://www.goodreads.com/quotes/tag/gaining-knowledge accessed 24th October 2021