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RESEARCH ARTICLE

Information and Communications Technology (ICT) Impact on Architects: Disruption and Hybridization Process

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ABSTRACT
Information and Communications Technology (ICT) impact and adaptation issues to emerging technologies have been widely researched in many sectors, as information has become vital to any business activity. Architectural practice, as an information-centric profession, is directly affected by the transformation and development of ICT. However, research on the impact of ICT on architects and architectural offices in Turkey has been limited. This study uses Grounded Theory methodology to study six cases with different ICT adaptation levels and workflows. The case study shows that architects can hybridize with new technology at the very beginning of the practice. However, increasing complexity due to the continuous transformation of ICT disrupts the habitat of hybrid architects. The disruption leads to a new hybridization phase, a complicated process for an architect who has to change the mindset of an earlier period.

Keywords: Information and Communication Technology (ICT), Architecture, Grounded Theory, Hybridization, Disruption

Introduction

Information and communication technology (ICT) is indispensable in modern life. In today's world, *acquiring, storing, retrieving, transferring, and disseminating information is almost impossible without using computers, telecommunications, micro-electronics, and their applications*"[1]. However, ICT, which is in use and well adopted by the sectors, continues to transform in parallel with new developments. The constant transformation of ICT has an effect on architecture, which is an information-centric practice (Kalay, 2006), today and had historically.

The first research on ICT developments affected architectural design in the 1960s, when information technologies began to be used (Pena, 1969; Alexander, 1970; Negroponte, 1975; Cross, 1977; Mitchell, 1977). The emergence of information technology has led to a radical change in the media of the communication process and the distribution, storage, and verification of information. Researchers have described the period starting from the mid-20th century[2] after the industrial age as a new age with different names: information age, digital age, or computer age in various resources (Castells, 1996); Lannana and Uy, 2003; Webster,2001). While the ICT developments began in the mid-20th century, the widespread use of new technologies took time. The diffusion of ICT to all sectors has increased, especially since the 1980s, with the general use of personal computers. ICTs became ubiquitous artifacts a decade later, in the 1990s (Mansell & Steinmuller, 2000). Freeman and Soete (1994) describe this diffusion process as the pervasive power of ICT; "*The pervasiveness of ICTs is not just a question of a few products or industries but of a technology which affects every industry and every service, their interrelationships and indeed the whole way of life of industrial societies*."

In the 1990s, with its pervasive power, ICT diffused more into architectural design. Architects began to question these transformations and attempted to find their positions. For example, Eisenman (1992) defined this situation as a paradigm shift from mechanical to electronic and asked, "*How have these developments affected architecture?*"

Nearly 40 years have passed since Eisenman asked about the effects of ICT on architecture. This question is still relevant, as developments in ICT continue to transform architectural practices. Within the last 40 years, architects learned to manipulate the

[1] https://www.lisedunetwork.com/ict-concepts-and-meaning-definition/
[2] Alberts at al (1997), The Information Age: An Anthology on its Impact and Consequences can be checked for a brief history of ICT developments lived in the information age and before.

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design in real time with visual objects directly, used CAD technologies to reproduce the documents, and became familiar with the spline tool with the help of digital design (Carpo, 1992). According to McCullough (2006), "Design computing which is no longer 'just a tool' (in the apologetic sense of not influencing one's intentions), rapidly matured as a medium in which bias, appreciation, expression, and new genres were inevitable."

In the 2000s, a new shift started from CAD to BIM models. Jernigan describes BIM (Building Information Modelling) as; "*The management of information and the complex relationships between the social and technical resources that represent the complexity, collaboration, and interrelationships of today's organizations and environment*" (F., Jernigan, 2007). 2D CAD drawings and analog actions cannot handle fundamental concepts such as *complexity, collaborations, and interrelationships*. Consequently, the AEC sector started to use building information models (BIM) to integrate the increasing amount of information produced during the project.

Oxman (2006) marked early CAD models as an attempt to depart from paper-based media (Oxman, 2006); from her point of view, we can characterize BIM tools as an attempt to depart from CAD models. However, in the first years of BIM, the construction industry was not yet mature enough to understand the potential of computer-aided design as a decisional tool to support the entire construction process (Pavan et al., 2020). As a result, the majority of the actors in the building industry use BIM in a reductive manner (Kalay, 2006).

Nevertheless, the construction industry, one of the lowest-digitized sectors (Manyika, 2018), started to change. ICT developments had a positive impact on it. The construction industry has begun using computational tools, production technologies, and advanced digital applications more efficiently. This development has also affected research in this field. Lu et al. (2015), researching 635 ICT-related articles within the journals of AEC, finds out that (Figure 1) among the six types of various users, contractors, and subcontractors are the leading adopters of ICT. According to researchers, the increasing number of contractor-oriented articles results from the construction process, which demands massive and accurate information to make decisions and improve efficiency and performance.

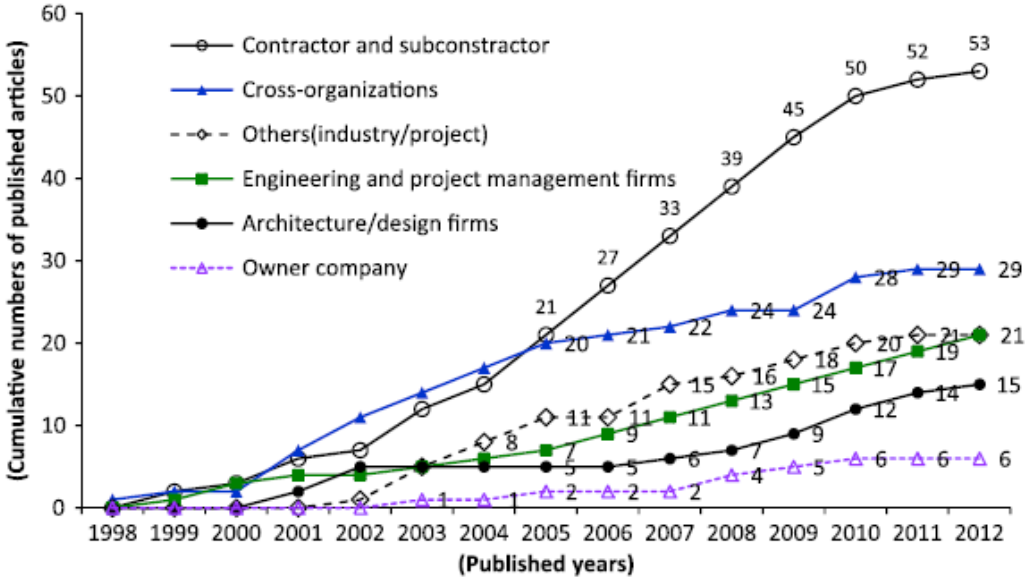

Figure 1. The cumulative number of ICT articles in the layer of organization of 12 total journals by publication years during 1998-2012 (Lu et al., 2015)

Lu et al. (2015) show that ironically, ICT adoption and the demand for research are less in architecture and design firms, unlike contractors. However, engineers demand more information than architects do for ICT adoption. Surprisingly, ICT's impact on architects and the profession has yet to receive much attention in the research field. Studies on practitioner reactions to developing technologies are rare.

While ICT transforms the habitat that architects practice, both in the research and practice fields, architects' reactions to this transformation can be defined as an externalizing process. Architects focus on their design objects, while new actors and consultants have arisen to cope with the increasing complexity of construction processes. The design process is changing, as there are new IT applications and construction techniques which architects are unfamiliar with. This change leads to the following research question.

- What are the possible outcomes of ICT that has an impact on architectural design process and how do architects react to technological developments?

Research Methodology

Information on the impact of ICT on Turkey's architectural figures and design processes is limited. As technology is developing at an increasing speed, the new culture of the architectural design field is reshaping continuously. The researcher is interested in the architect's subjective experience in his new culture, transforming it with the impact of ICT. To capture these objectives, researchers designed hypothesis-generating qualitative research using the grounded theory methodology. First, the research questions were shaped, and semi-structured interviews were conducted with six offices with different technology levels, structures, and working habits. In the analysis stage, data were examined in detail using the techniques described by Strauss and Corbin (1988).

Grounded theory is a general methodology with systematic guidelines for gathering and analyzing data to generate middle-range theory (Charmaz & Belgrave, 2007). Researchers prefer to use it mainly to reveal the reasons that affect the emergence of a phenomenon that is poorly understood and incomprehensible. The analytic process consists of coding data; developing, checking, and integrating theoretical categories; and writing analytic narratives throughout the inquiry. There are two main parts of the grounded theory: open and axial coding.

Glaser and Strauss (1967) propose that researchers collect and analyze data simultaneously. In grounded theory, from the beginning of the research process, the researcher codes the data, compares the data and codes, and identifies analytic leads and tentative categories to develop through further data collection (Charmaz & Belgrave, 2007).

In this study, audio data records were first decoded into texts. Subsequently, researchers explored recurrent patterns and variations to define codes in the open-coding phase. These codes were used to construct distinct categories using axial coding. Categories were linked in the selective coding phase, leading to research themes. (Figure 2)

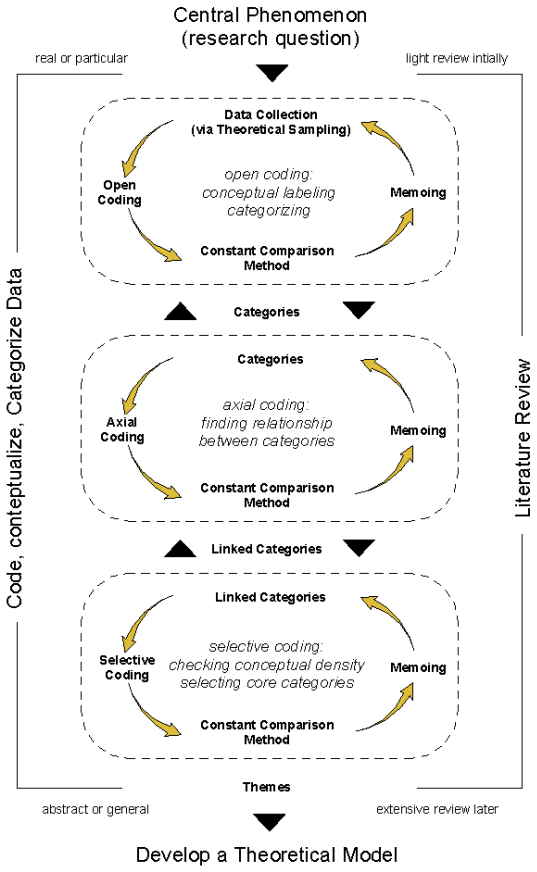

Figure 2. The research Model of the Case Study was adapted from Hoda et al. (2012).

Corbin and Strauss (1988) mentioned paradigm-based coding as an analytical tool to help analysts carry out axial coding or

coding around a category. It consists of 3 main features: conditions, actions, and consequences. However, during the coding phase, the researcher realized that capturing actions-interactions provided limited information for creating the categories' central ideas.

Participants mainly mentioned their values or attributes to the conditions and did not want to provide much detail about their actions. Therefore, to capture any meaning that a sentence can hide, we used a 5-labeled coding process in the open coding phase: open coding, process coding, descriptive coding, values and attribute coding, and emotional coding.

Open coding is the first impression of what the participant mentions and how he or she describes causal conditions. Something happens, and the participants must mention it or talk about a situation, trying to explain why the this phenomenon or paradigm change happened. Process coding describes the actions or interactions of a participant. Participants developed these actions as a strategy because of this phenomenon. Descriptive coding labels the object of a sentence as a participant. Codes explaining the values and attributes were shaped as a vital header because the participants mostly talked about their beliefs, values, and attributes. Instead of describing their exact process in architectural design, they mostly share their opinions about how it should be, how an architect should behave, or their difference from others who work as a cogwheel of the system. The emotional coding label explains whether the participant shares emotions such as happiness or fear.

After the first coding phase, axial coding was performed to link the categories and subcategories into a broader framework. Following axial coding, the selective coding phase was initiated. In the selective coding phase, categories are integrated and refined into themes. For example, it has emerged from axial coding that personal values, the mindset of architects, and their concerns are shaped through the transformation of ICT.

Participant Profiles

The six architects who participated in this case study lived in Istanbul. Two architects run the architectural firm independently: four architects have partners and three have partners with their spouses. Members of the study group were born between the years 1964-1980. This range can provide clues about whether age plays a role in the impact of ICT on architects, as the participants faced a technological revolution at different ages and positions.

Five of the six participants graduated from Istanbul Technical University (ITU). Only one participant was from Yıldız Technical University. Five of the six participants had a master's degree, three had master's degrees taken abroad, and two were from ITU. Unlike other participants, one of the participants was a Professor at ITU while simultaneously working as a professional architect. Two participants had experience of working abroad.

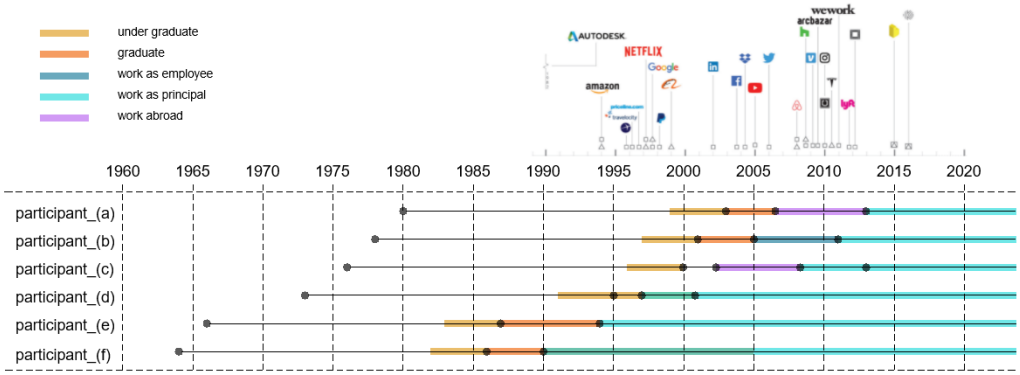

Figure 3. Participant profiles: Education and work experience, combined with Bartling, R.J. (2019)

RESULTS

The data analysis from open coding to categories reveals the emergence of three themes: the effect of the increasing complexity of the issues not related to the architectural design process, the traces of disruption in the personal sphere of the architect, and the hybridization process with the emerging technologies to cope with the complexity,

The effect of the increasing complexity of issues is unrelated to the architectural design process.

The architects mentioned various issues not related to the professional field of architecture, but that affected their design process. These issues are grouped under increasing complexity, mostly referred to as new conditions or challenges that they have not faced before. Architects describe increased complexity in three subcategories: increasing information exchange, increasing uncertainty, and decreasing project time and budget. In the interviews, architects linked increasing complexity to the increasing scale and detail level of new buildings (Figure 4).

The increasing amount of information exchange:

The participants stated that project actors and new specialties have increased in recent decades. Architects link this increase to increasing scale and detail levels, and to contemporary issues emerging in the world, such as the climate crisis. In addition, expertise has been divided into different areas, especially in engineering, so there is a natural increase in the number of actors involved. Some participants described this division as a breakthrough for the engineers. As a result, architects must coordinate with more consultants than before. The communication process extends as they talk to all actors in the project and listen to all their comments. The increase in communication creates a greater information load for architects who manage coordination. However, for some architects, managing this information process can make the work enjoyable for other actors in the project. One architect also highlighted that information could become junk if it is not managed. Some architects use digital tools, such as BimDocs by Autodesk, to manage information flow. According to Participant_(f), the increase in the number of consultants is a new fact; however, today, what makes it different from the past is the accurate management of information with digital tools. It can be said that coping with this new workload becomes uneasy without digital tools due to the new conditions of the complex environment.

Increasing Uncertainty

Increasing uncertainty has emerged as a phenomenon affecting the progress of the architectural design process and the way of managing business and decisions for the future. The most mentioned sub-category of this phenomenon is the client's uncertainty, which directly impacts the management of the design process. According to architects, clients were uncertain and could not decide from the beginning of the project. As a result, major changes occur very late in the project. To cope with this uncertainty, architects have attempted to extend the time of the preliminary project phase as a solution. Another solution is to keep the client in the process from the beginning. However, even if architects settle the building program with the client, this process brings the client criticism of the program.

Similarly, long waiting and evaluation times with long decision processes can be read as client uncertainty. In contrast to the other participants, one architect defined uncertainty as a typical situation in this era and emphasized that he designed it accordingly. Another architect mentioned that uncertainty is a concept that creates space for people to stay in the gray zone, where many actors feel safe not to make decisions.

Another sub-category of increasing uncertainty has been shaped as 'the lack of an appropriate budget.' This subcategory occurred at different times during the interviews as a disincentive factor. A crisis occurs every ten years, which makes it impossible to invest in the firm without financial precision. The budget problem is defined as not only limited to the firm's future, but also the labor working for the office. Architects compare their budgets with Western countries and describe themselves as having low project budgets, which is a problem that prevents working with necessary consultants. A low budget is also defined as a problem for engineers, as it does not allow them to invest in software or training to collaborate with the architect's team. Another point of view highlighted by one architect is the client's budget, as he believes that clients are working with him since he can protect their budgets in this uncertain era.

While five architects used negative statements for the concept of uncertainty, one architect used a different approach. According to him, digitization can be defined as both uncertainty and flexibility. Before this era, the time, budget, and project targets were stable, unlike today. The architect mentioned that he did not see a low budget as a problem in his practice. This is probably due to the economic structure of his office. His work model differs from those of other offices. He calls a sponsored design service, making a long-term contract with a construction firm and maintaining a constant payment for his services.

Decreasing Time and Time Management

The increase in the scale of buildings increases the information level and communication workload of architects, both with the client and within the architectural design process, resulting in a time-limitation situation. Architects are trying to spend more time thinking about the process, but cannot, as they experience time pressure. The phrases used as a negative expression are "compete against time," "time pressure," "spare time," and "isolate me to use time better." The increasing time pressure on architects has been defined as a specific property of today since the 1990s. However, while five architects discussed the time pressure on them or their design process, one architect did not mention this issue. This is probably due to his working methods and process management. From this point of view, another architect added that to manage time better, they were refusing projects impossible to finish in a logical time.

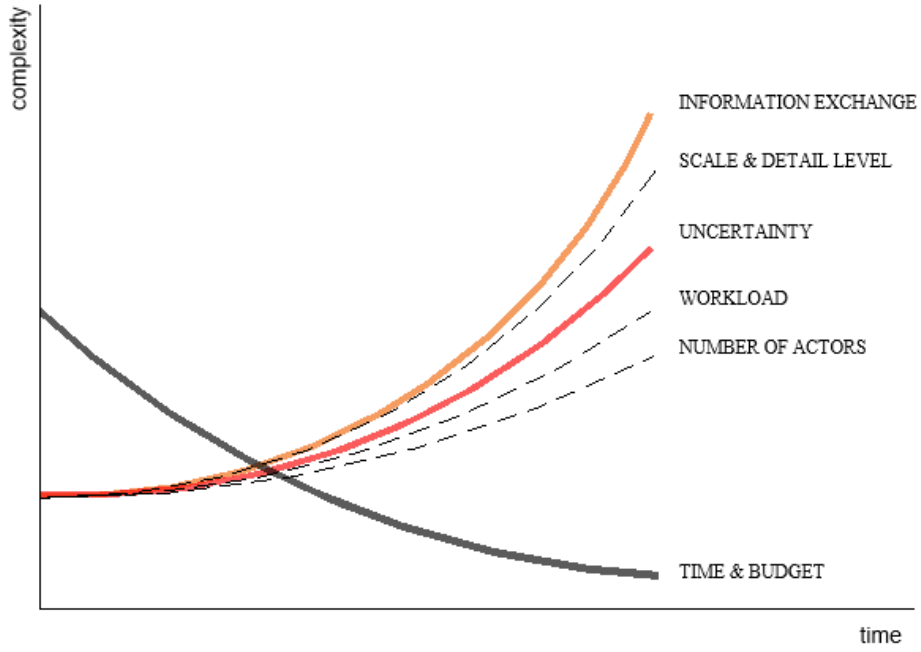

Figure 4. Architects' perceptions of complexity in project workflow.

Traces of disruption in architects' personal spheres

Absorption of digital technologies without changing the analog mindset

Data analysis showed the 'mindset' as a central concept. The participants discussed analog and digital mindsets. Architects highlighted that they did not believe that the mindset of architects changed in parallel with the developments in ICT (Figure 5). While architects use tools with the mindset of the analog period, they are also reluctant to change the tools they use or how they use them because it is difficult to change their comfort zone.

The comfort zone emerged as a sub-category that prevented changes in working processes. Employees and firm owners do not want to change their comfort zones. It can be understood that the way architects are accustomed to is the most feasible way to complete their issues. The comfort zone is the space in which they act the best. This comfort zone is so strict that it allows employees to resign. For example, one participant's motivation to transform the office was stuck in the employees' comfort zones, which led to their loss. Another participant mentioned that it was difficult to change the habits of the architects. They cannot change employees' comfort zones even if they provide enough time and resources. This situation can be explained by an analog mindset situation. Even though tools or resources have changed, architects cannot quickly digitalize or adapt to a digital mindset. Some architects defined themselves as architects of the analog period, as an extension of the twentieth century. They described the education system of the twentieth century. Architects continue to use the methods they learn. Another participant described himself and his generation as having a linear mindset. However, when the same participant mentioned his office, unlike himself, he highlighted that their minds work digitally.

Working in a digitally configured office structure allows analog-minded architects to cope with the digital complexities. One participant described himself and his generation as having a mindset that had to be changed to catch the transformation or communicate with the new generation. According to him, architects must also change their mindsets to catch up with clients.

The significant separation of the 'world of thought' & 'world of operation':

Participants mostly separated the idea world from the operational world. As mentioned, ideas are often shaped through an architect's mind; the tools are part of the operational world that helps visualize or develop this idea into construction documents.

One participant highlighted that the 'idea world' of the architect is independent of the tools, giving the example of the architects of analog periods who were able to construct without digitized tools. As computers' idea generation process is also dependent upon humans, ICT can only be an assistant for the idea to rise, unlike paper or pen. They also believe that BIM or other software is not directly linked to the production of architectural thought. Participant_(b) stated that he could produce answers independently and did not need any tools to help him find these answers. He also emphasized that their problem was not about creating ideas or

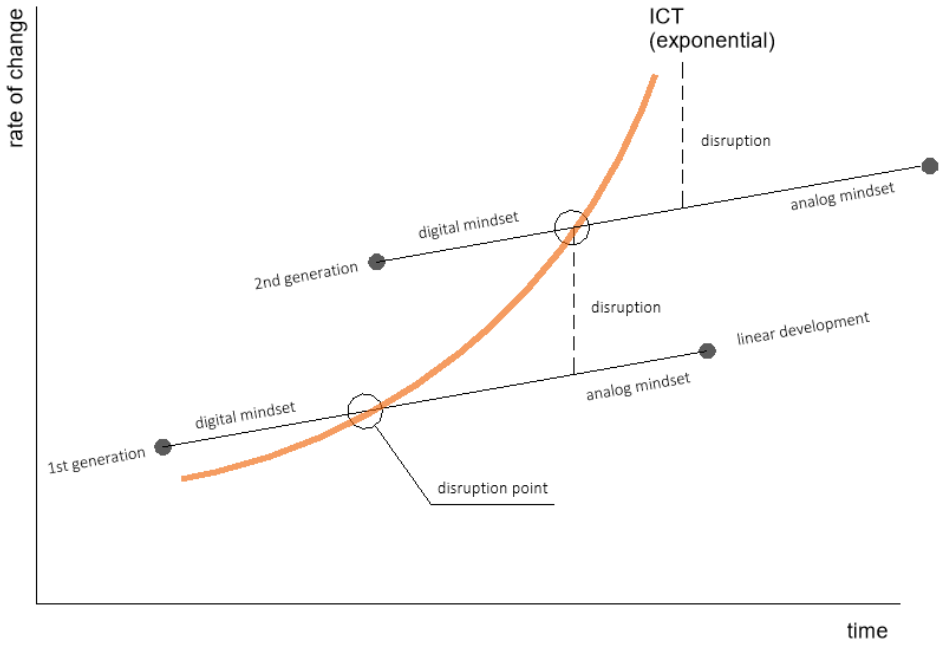

Figure 5. Disruption of architects through exponential development of ICT

designing itself. It can be said that until he sees an issue, he will not use any tools to assist him. 'Sense of space' and 'idea of the building' are more important concepts for the architects than the model produced to view the idea.

The separation of the 'idea world' is essential for defining the architect himself. Participant_(f) clearly stated the importance of asking questions about architecture rather than using tools.

Unlike other participants, Participant_(d) mentioned that the main idea is not shaped within the brain of the leading architect, but is a common idea of the office. According to him, he was using the analysis of the tools, but the idea was coming through the architect anyhow. However, one participant who used BIM tools more than the other participants stated the opposite. He mentioned that the design is not a separate process. Moreover, he did not see computers as simple tools, but saw himself as a tool for computers.

Even if the 'idea world' is separated from the tools used by architects, a connection is highlighted by the participants. It has been stated that the interpretation of ideas in digital space changes with the transformation of tools. Computer-aided numerical data are also involved, inevitably causing architects to interpret the information in the main idea. Architects emphasized that the operational world is separate from the thought world, but the operational world's tools support the thought world. With these new tools, architects can test their choices based on intuition.

Architects are attempting to relocate themselves to the digital world:

The data analysis shows that architects try to change their working methods and thinking patterns according to the new digitized workflows to adapt to the new digital mindset. Digital mindsets are open, transparent, shared, and easily accessible (Show et al., 2022). However, in this adoption process, architects raise negative projections for the future, mentioning concerns about the new generation with new abilities and tools.

A sub-category that emerged under this category was fear of losing control. Architects at the center of information flow are essential in the design process. The change in tools or actors in the design process can damage this central position. Participant_(b) mentioned that he was using the software that he knew because he wanted to control the entire process through the tools he used.

Participant_(e) knows that the transformation is ongoing and attempts to understand the changes. However, he is afraid of living a break with the new generation. Like participant_(e), participant_(c) is also afraid of a break with the new generation, so he tries to try new technologies and catch up with the digitization process. Participant_(d) also tries to catch up with new technologies, such as participant_(c). He mentioned his fear of new technologies being able to do what he could do as an architect. Nevertheless, he is not concerned, as he learned that there is still time. Participant_(a) stated an issue similar to that of participant_(d). According to her, software can quickly publish an application project. Moreover, she believes that this is an issue that architects fear.

Collaboration with the new generation is another action that architects have taken to locate themselves in the digital era. Participant_(d) described himself as a design manager who tried to collaborate with his team. However, it should be noted that he

could not use the software used by the design team. This handicap could be a reason for Participant_(d) to collaborate with his design team to survive in the digital workflow.

Unlike participant_(d), participant_(b) used the same software as the design team. According to Participant _(b), lead architects should be able to use the same software; otherwise, there would be an instrumental break. However, the software used in the office is not a contemporary BIM or parametric tool. In the case of any need to change the tools used, participant_(b) can experience a disruption in the work process. He did not mention catching up with new technologies or software.

Hybridization with emerging technologies to cope with complexity.

As seen in the previous section, ICT's transformation of daily life and sectors impacted the architectural design process. Architects have been working to hybridize digital tools to cope with issues that do not occur within the profession. Some participants relied on available technologies that had been internalized before. Others collaborate with the new generation, which can use emerging technologies.

The hybridization process has two main subcategories: hybridization with information technologies and hybridization with communication technologies. As information technology architects use changes rapidly, hybridization with information technologies can be defined as an issue that is more familiar to architects. However, hybridization with communication technologies can be relatively new because of the wide usage of the Internet and social media over the last few decades.

Hybridization with information technologies:

The interviews showed that software selection in a project is mainly related to time management. Participants highlighted that they mostly chose the software according to the time they could spend on the project. The software can be a modeling tool or a project management tool. These tools are seen as a possibility of gaining more time with them. They mentioned that if they have limited time, they can change working methods, such as using a sketch-up model instead of making a physical model to see around.

Interestingly, architects quickly return to their habits and methods they are accustomed to in the case of time limitations. Unfortunately, the time allocated to the project phase is limited in Turkey. A limited time can be seen as limiting the development of architectural design offices. However, Participant_(f) had a different perspective. According to him, even if architects are given the necessary time, they cannot change their working habits.

This situation was coded in the previous theme as a mindset change and reluctance to change the comfort zone. ICT disrupts architects' comfort zones. For example, participant_(e) prefers not to use new technologies in his workflow because he thinks they are slowing him down. Nevertheless, he was sure that digital technologies did not change his way of thinking, but changed the time he spent. Like Participant_(e), Participant _(f) noted that generative design solutions to generate new geometries could be an option for obtaining short-term solutions.

Participant_(a) also linked the methods used in the project and was directly related to the time issue. The variations created within the software helped her manage the time better. However, creating more variations and looking at other options are linked to the architect's time.

The creation of variations is essential for architects. However, variation-making is a time-consuming process. The variations created within the software help architects better manage time. It can be said that before digitalization, architects needed to limit the alternatives they could produce because of real-life limits. However, architects believe that digital tools remove these limits and allow architects to recapture the other options they have left out.

Another participant emphasized that the usefulness of digital technologies was the ability to simulate the project. The study participants saw the possibility of seeing a digital model representing the real as an important feature.

Participant_(b) highlighted that the simulations are valuable for seeing the design as it is in real life, which is vital for capturing the atmosphere of the building. Architects use digital technologies to capture what is essential to the design process. For example, participant_(b) found that the sense of space is a critical value in architectural design. Thus, he was looking for digital tools to help capture the feeling of space. Unlike participant_(b), participant_(c) determines the calculations of the 3D model that are important for the design process. So, what he understands from simulating the building is not the architectural elements, but the calculable value of the model.

The expectations from the simulation also affected the programs used for the simulation. Participant_(c) only used Revit for creating 3D models; they are all BIM models that include parametric information buried in objects. However, participants (b) and (e) used Lumion as a simulation tool. It should be noted that Lumion, a simultaneous render software, unlike BIM tools, only provides visual data with the textures of the modeled design.

According to the participant, participant_(f) simulations were performed to determine alternative solutions and possibilities. Nevertheless, Participant_(d) stated that simulations should be performed with the manufacturers' elements as they will be produced. In this manner, the model can represent any problems that may occur during construction.

Architects find digital tools useful for capturing the architect's 'idea world' into a digital model that other parties can see. This digital model helps them interact with people and discuss ideas. Participant_(c) mentioned that with digital media, information about the project could be taken out of the architects' minds, and it can be reachable by anyone in the project.

Digital tools also help architects overcome other limitations such as distance. While Participant _(e) highlighted that technology should not dominate the design field, he appreciated the value of sharing the project with clients via digital tools. Participant_(f) considers platforms such as BIMdocs to be valuable in protecting the information produced during the project phases. Participant_(a) also used BIMdocs in her worldwide project to share her documentation.

Participant_(a) highlighted another issue that digital tools are capable of. According to her, architects can protect their designs using digital world tools. Because there is a simulated model of the project, changes in construction performed by constructors can be limited. With the 2D projection of the design, it is a well-known issue that most of the information is divided into parts, and most of the time, the constructors cannot construct as defined in the project.

While all the participants appreciated the various digital tools they used, they also highlighted the limitations of the new tools.

When discussing generative design, participant_(d) mentioned that adaptation to new technologies requires time. He provides an example of their adaptation to BIM platforms. Participant_(e) highlighted that catching up with new technologies requires time. Nevertheless, he also mentioned that when a break occurs, it becomes more difficult to communicate with others as they will be talking in another language.

Another topic regarding the limitations of new tools is the cost of new technology. As software is sold in international currencies, in the context of Turkey, it becomes unaffordable to buy that software. Participant_(e) complained that while they wanted to build a digital environment, they could not get the budget for this extra effort. Participant_(d) describes buying new software as "burying the money into it." Investment in new software can be considered necessary if the current tool can be used in the same situation. Participant_(f) described this situation as a question because not everyone can access it. Consequently, new digital tools have become pervasive. Participant_(a) addressed the cost of new technologies as a limitation. She added that she could not find engineers to work in BIM since engineers could not invest in new software because of the high cost. According to Participant_(f), the exact reason for architects and engineers not working in the BIM-based software can be counted. Participant_(e) was aware of the shift to new software. However, he was not ready to pay the cost of the new hardware and software required.

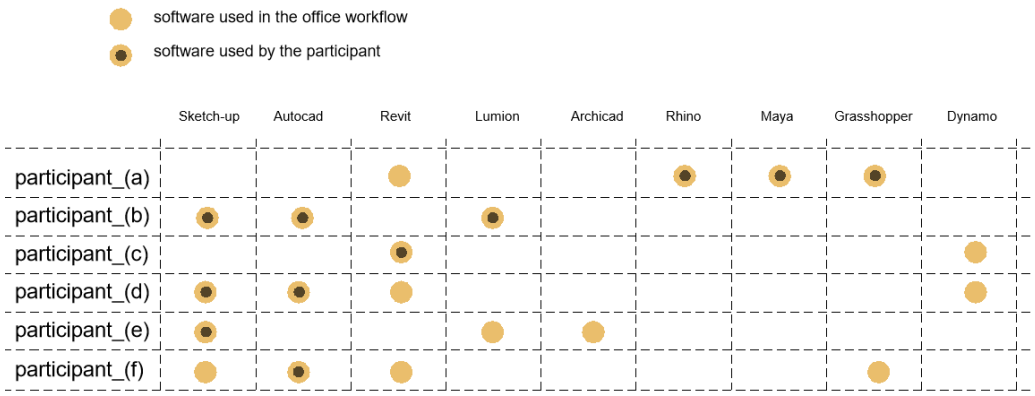

Figure 6. Software usage of participants' office structures.

Hybridization with the communication technologies:

During the interviews, participant_(f) stated that he saw the transformation of communication technologies as affecting architecture more than the transformation of tools related to architecture. He indicated that communication technologies, such as Pinterest are changing how architects reach architectural knowledge, which is reduced to visual data, independent of its context.

There is no consensus regarding the use of social media. While some participants did not approve of social media use as a world of images without any context, some saw the images as similar to the pictures in magazine clients who were accustomed to. Participant_(d) considered Pinterest a site forbidden in the architectural studio. Unlike participant_(d), participant_(b) mentioned the Pinterest architecture as good. Similarly, during his narration on social media, Participant _(e) highlighted the importance of Pinterest for him, replacing the magazines he buys in his office.

For participant_(a), using social media such as Pinterest is a must-be, but she added that she is not searching to feed herself with the images, but to know what is being built in other parts of the world. This approach can be coded as maintaining communication with others through social media. Participant_(b) highlighted that their last project could only be conducted with social media and communication through it. He describes these online works as encounters.

Whether the participants found it useful or not, it was seen in the interviews that communication through social media and other media is increasing. This increase creates constant communication with the client, other parties, and architect. Participant_(a)

highlighted that digital tools enable the brain to communicate better than before. Participant_(b) added that increased communication created a more demanding client. This more demanding client can also relate to architects' increasing time pressure and workload. However, participant_(b) seemed to be used in this communication, and he added that they had to keep it constant.

DISCUSSION

By exploring the impact of ICT on different profiles of architectural offices in Turkey, this study aims to understand the transformations occurring within the architectural design process and in the personal sphere of architects.

The study's findings showed that the rapid development of ICTs disrupts architects' architectural design processes and personal spheres. To overcome this disruption, architects have attempted to hybridize with emerging technologies. The hybridization process was found to be linked to the disruption level of the habits and mindset of the architect.

The two concepts emerging from the data analysis, "Disruption of the architect" and "Hybridization of the architect," will be discussed in this section.

Disruption of the architect

According to Floridi L. (2015), the world is grasped by the human mind through concepts. Concepts provide an understanding of surrounding realities and a means to apprehend them. Floridi (2015) highlighted that the current conceptual toolbox of humans is not suitable for addressing new ICT-related challenges. Consequently, negative projections will arise in the future. It can be seen from the case study that the conceptual toolbox of architects to understand the world and act in the architectural design process does not address new challenges. This situation leads to disruption of architects' personal spheres. As new methods, technologies, and procedures emerge, architects are trying to relocate themselves to the digital world to overcome this disruption.

In general terms, 'disruption' has multiple meanings, ranging from prevention, disturbance, disorder, disassembly, to interruption[3]. In this study, the disruption concept is used for technological transformation that affects the traditional architectural design process and prevents it from continuing as expected.

Disruption occurs when technology changes the rules of the market, lives of people, or society. According to Picon (2019), "for the past 20 years, architectural practice is facing an extremely rapid pace through the development of digital tools, and this pace is not letting the theorists and historians think, write or make sense of the design methodologies like BIM or Parametric Design. This pace is also not letting the professional standards be set or completely clear." It should be considered that new digital tools and their use are still new to architectural practice compared to the drawing habits and methods that have been ongoing for centuries. Traditional workflows are transformed mainly by new technology; therefore, practices such as architecture must adapt to this recent change. However, when adaptation occurs, practices become irreversibly changed, and their purposes and values are displaced by the qualities and capabilities of new technologies (Kalay, 2006). This displacement is conceptualized as the disruption of the architect and design process in this study.

It was mentioned in the literature review that the development of ICT has constantly disrupted the architect and design processes. Architects have adapted CAD tools that enable the production of contract documents more precisely and efficiently. They were then adapted to computer modeling to reduce construction costs and improve coordination. The development of networking and communication tools has made architects, experts, consultants, and other actors more frequently involved in the design process. VR and AR technologies have enabled the communication between architects and clients to improve in a hybrid world. However, a case study analysis showed that this adaptation process is mostly interrupted by negative values of architects, such as habits, typical workflow, comfort zones, and unwillingness to use new tools.

Negative values create an axis of mindset that does not change at a pace parallel to technological developments. Architects can use new digital technologies; however, their mindsets work analogously. As a result, disruption occurs in the personal sphere of architects with the absorption of new tools, without changing the analog mindset of old technologies. Kalay's (2006) two paradigms, "square peg in the hole" and "horseless carriage", can be used to discuss this disruption.

According to Kalay (2006), two paradigms in architecture happen through disruption. One is about the tools and the other is about architects' perceptions. The first is forcing a square peg into a round hole, which can be defined as new tools that are wrongly implicated or whose usage does not fit the processes that have traditionally been part of architectural design. Using precise drafting tools, where ambiguity and flexibility are required, can be seen as an example of forcing a square peg into a round hole. The relationship between a tool and a task should be functional, as new technology is introduced into practice. Otherwise, the technology results in a poorer practice. This paradigm can explain the frequent use of sketch-up models in architectural practice. Google, a company with no background in construction projects, has developed SketchUp. This tool has become very popular, as it allows architects to model the virtual environment. In a case study, architects defined modeling in Sketchup as cutting a

[3] https://dictionary.cambridge.org/tr/s%C3%B6zl%C3%BCk/ingilizce/disrupt

physical model, which is a traditional habit of the design process. While a similar action can be performed in parametric software with visual coding, the architect's mindset is stuck in a traditional workflow and prefers to use a tool similar to older habits. A similar situation was observed in BIM modeling software such as Revit and Archicad. This software is a complex modeling tool that requires a precise information set. As a result, they could not represent the ambiguity and flexibility that designers needed at the very beginning of a project. The square pegs did not fit the round holes. Visual coding tools such as Dynamo for Revit and Grasshopper for Archicad were developed to increase flexibility and enable software to be used in the first design phases. Therefore, they started rounding them off to fit into the round holes. However, as seen in the case study, while the software has developed to new parametric extents, some architects mentioned that they prefer using tools related to their previous practices, like cutting a physical model. Moreover, the architects who did not show any signs of adapting to new parametric tools themselves frequently mentioned collaborating with new generations who could use these tools.

The second paradigm, *horseless carriage*, describes a state of transformation, where the new technology is viewed through the lens of the practice in obsolete and 'backward' terms. This situation was seen in the early 20th century when the automobile was considered a horseless carriage. This implies a lack of appreciation for the emerging potential of technology in changing the task to which it is applied (Chastain et al., 2002). The paradigm is mainly concerned with the transformation of the designer's perception. The paradigm comes from the first use of automobiles, and people see them as horseless carriages. According to Kalay (2006), this paradigm assumes that the fundamental task does not change, as in the first case. However, unlike the first paradigm, it assumes that the practice of design is not only assisted, but also changed through the influence of new technologies. It can be said that the latest digital tools and their use is still new to the architectural practice compared to the drawing habits and methods that have been ongoing for centuries. Bartling (2019) provided an example of BIM use in this paradigm. He uses the term 'underutilized assets. According to him, while big firms are fully integrated with BIM, they constrain it to a computer-aided design (CAD) approach and limit their capabilities. The habits and methods of historical development of architectural practices continue. Having signed flattened 2D drawings for legal procedures remains standard. Architects in the case study were aware of the developments in BIM, but they saw it as an operational space separated from the concept design or idea world. While BIM is a new perception in the construction industry, architects lack appreciation for this emerging potential technology. This may be because BIM and algorithmic models disrupt the architect's traditional informational workflow. Architects used to be at the center of information, but with BIM, the model is at the center of information. With the traditional workflow, the design information is cut in at each phase, and the architect's own knowledge becomes the main source of the lost information. But in contemporary complex workflow, information is kept in the models mapping on each other until the construction is complete (Figure 7)

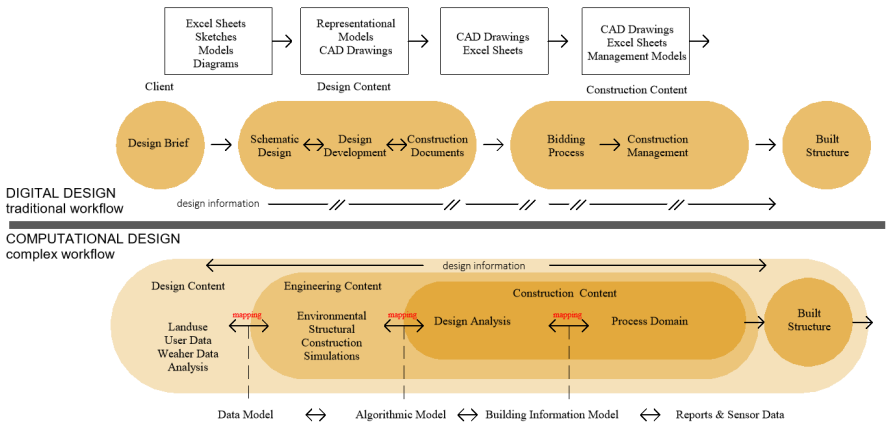

Figure 7. Transformation of design workflow and information management with computational design. Adapted from Pantazis and Gerber (2019).

Hybridization of the architect

"The progressive increase in relations between the virtual world and the real world, in conjunction with the spread of new ICT, is radically changing the ways the two worlds interact, giving rise to hybrid realities, as documented in numerous studies conducted in recent years in literature and multiple applications presented in architecture"(Chiesa, 2020).

Hybridization has recently been discussed in contemporary culture research. While it can be referred to as a term in poststructuralist cultural theory, today, it is used especially in the context of disputes about cultural globalization and the interpenetration of cultures (Ptichnikova, 2020). Nederveen (1995), developing this concept to explain global modernity, argues that globalization has contributed to strengthening the processes of heterogeneity, expressed in the diversity of forms suddenly joining each other and giving rise to entirely new entities. In architectural design, the hybridization concept is mainly used to describe or explain

the functional, formalistic, or typologic schemas of designs (Ptichnikova, 2020). Broaweys defines two types of hybridization: the development of materials and the hybridization of reality with digital elements. Chiesa also mentioned two different characteristics of hybridization, pointing out further research. The first is the reduction of boundaries between real and virtual worlds (Sakamoto & Ferré, 2008; Sass & Oxman, 2006; Oxman, 2006; Mitchell, 2005; Milgram & Colquhoun, 1999; Negroponte, 1995). The second is the hybridization of natural and artificial worlds. (Hochberg et al., 2012; Gruber, 2011; Chiesa, 2010; Bar-Cohen, 2006; Benyus, 1997; Gérardin, 1968)

However, in this research, the hybridization concept is not discussed within these definitions. It is used as its first meaning in the Oxford Dictionary:

"The process of breeding together animals or plants of different species or varieties to produce a hybrid"

According to the findings of this case study, architects and digital tools are being bred together to produce a hybrid. It can be said that ICT constantly transforms the habitat of architects as they create extreme conditions. The increasing scale of buildings, increasing level of detail parallel to CAD software, increasing workload with the 3D modeling of every building part, increasing information exchange due to new specialties and actors involved, and the decrease in budget and time limitations define a new habitat. In biology, chemistry, agriculture, or stock farming, to cope with the extreme condition's hybrid species are needed to cope with extreme conditions. Similar to other sectors, architects try to hybridize with digital tools to cope with the complexities of their new habitat.

However, hybridizing with ICT in this new habitat is challenging for architects. Architects can be viewed as species whose boundaries are strictly defined through education. Harrison and Larson (2014) defined species as "populations that are diagnosably distinct, reproductively isolated, cohesive, or exclusive groups of organisms." In this case study, most participants accused the education system of teaching architecture students, such as master architects, who are isolated from other disciplines, while the profession needs otherwise. Parallel to the education system, the first years of working in a classical office structure solidify, creating an analog mindset within architects. Consequently, hybridization with emerging ICTs has become a problematic issue.

Through paradigm-based data analysis of participant profiles, it was observed that some participants were able to hybridize with the technologies of the first digital turn (2D CAD technologies, essential modeling software, etc.). However, their working processes and methods are being disrupted with emerging technologies and the new generation. This result suggests that disruption and hybridization occur in the Mobius circle. In addition, architect hybridization is similar to hybridization in biology in that hybrid species are fertile.

The hybridized architect can be described as a fertile species because it can be seen from the participants' declarations that the hybridization process of the architect is directly linked to the values and mindset of the architect, and values cannot be transferred. Even if the manager of an office tries to force employees to adapt to new technologies, this only happens when the employee feels that it is lacking. Alternatively, in another case, the manager does not try to hybridize with the new technology because he feels safe in his comfort zone. He mentioned that he did not see any lack thereof.

Disruption & Hybridization as a continuous process cycle

Architects are used in traditional workflow. However, their workflow is not capable of solving the new complexities of the digital era. Disruption of habitats is inevitable. After the disruption phase, the hybridization phase starts with computational tools. However, as seen in this case study, the hybridization process was mostly interrupted by the values, beliefs, or attitudes of the architect. In the first phase of hybridization, architects try to use the new software, maintaining an analog mindset. They try to collaborate with the new generation, which is already hybridized with the new workflows being born into. When architects are accustomed to new computational workflows, their mindset adapts to new digital patterns. However, new ICT developments will soon create a new disruption phase, which can be described as a continuous process cycle (Figure 8).

CONCLUSION

It can be said that ICT transformation directly and indirectly impacts architects. Architects are familiar with the direct changes that occur in information technologies. However, the indirect change that emerged as complexity increased was more challenging for architects. With ICT developments, complexity increases, and the habitat in which architects live, produce, and communicate is transformed. Architects with analog mindsets cannot transform their beliefs, attitudes, habits, and comfort zones at the same speed as ICT's transformation. We conceptualized this phenomenon as a disruption of the architect's personal sphere. To compete with these challenges, architects have attempted to hybridize with the new habitat of digital tools. In this sense, they also try to collaborate with the new generations.

With the hybridization process, a new hybrid architecture was created. Maintaining the beliefs, attributes, and values of an earlier period of knowledge, they can use the tools of the new digital era. However, this makes architects see digital developments as simple tools of the operational world or as *horseless carriages*. However, unlike architects with an analog mindset, the new

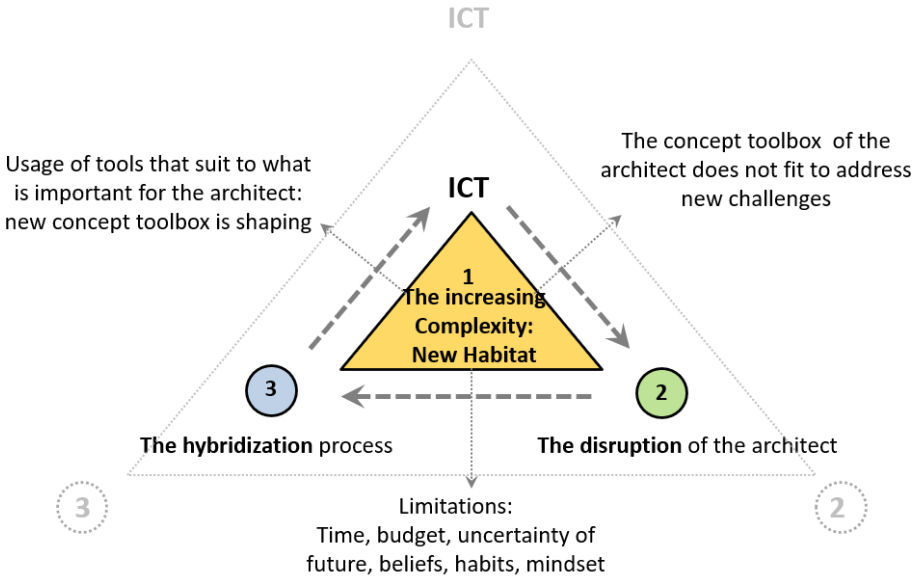

Figure 8. Complexity, Disruption, and Hybridization Continuity

generation born into this digital world can internalize and live much more easily in the digital habitat until new ICT developments disrupt them.

In future research, based on the themes developed in this study, a quantitative research methodology can be used to capture the hybridization level of architects.

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