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Technological innovation in architecture and engineering education - an investigation on three generations from Turkey

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Abstract

The developments in technology have caused many radical changes in the curriculum of architecture and engineering (a/e) disciplines. At the same time, generations and their personal characteristics are in continuous change that is shaping newer education techniques. In this context, this study is aimed to compare the educational perceptions of generations X, Y and Z for the advancements in the curriculum. For this purpose, a literature review concerning the technological advancements in education and characteristics of X, Y, and Z generations are demonstrated. Then, a survey was conducted on 160 respondents to differ the perceptions between these generations while considering the respondents' educational and social-related features. Results of this study support that Information Technology (IT)-related education is insufficient for the upcoming generations who were born and grew in the digital age. Generation Y is the least satisfied with IT-related lectures and more affected by the movement of sustainability. The perceptions between the generations are found statistically different and solutions are offered for the upcoming generations. The outcomes of this study are expected to guide professionals in a/e education to better fulfill the expectations of the upcoming generations.

Keywords: Higher education, Information technology, Architecture, Engineering, Turkey, Generation Z

Introduction

Lately, the construction industry is facing substantial technological transformations that enrich both architecture and engineering (a/e) curricula. Advances in technology have led to changes in the perception of individuals for education in the construction industry. Today's graduates need to develop broader perspectives to consider both cost, time and quality constraints with social, environmental and lifecycle related economic factors (Becerik-Gerber, Gerber, & Ku, 2011; Johnson & Gunderson, 2009). A project could only be completed with the unity of knowledge and imagination, where technology has become an essential part of the equation. Relatively new approaches and

computer skills are thought in universities to increase the satisfaction of education while fitting the market and employer expectations (Abudayyeh et al., 2004; Ebner & Holzinger, 2007).

Education always remains one of the most up-to-date concepts of language and culture (Dogan, 2008) and marks the human upbringing which enhances the construction industry formatively. Education could be defined as the art of raising people for a certain purpose, where changes occur in knowledge, skills, attitudes, and values (Fidan & Erden, 1998; Inal, 2004). Teaching is within the concept of education which is the work of giving education for a certain purpose (Sekin, 2013). The teaching process should be compatible with changing student profiles and develop over time. In other words, different educational needs among generations also should result in different educational models (Bates, 2005). In the theory and practice courses in a/e education, updates/innovations revived and educational tools are modernized (Akrout & Roxin, 1999; Brito et al., 2017). For example, traditional expression processes have converted into design classes and computer-aided programs are used as tools in the process of visualization. Therefore, the characteristics of different generations influenced a/e education which led to the introduction of more interactive and collective educational models (Ibrahim & Kurilovas, 2016). However, these models need to be constantly questioned whether they conform to the requirements of the age (Lokce, 2013).

In this study, the concepts of X, Y and Z generations and their characteristics are profoundly identified with literature. Also, a/e education-related studies are examined. The survey is aimed to explore the effect of developing technology on the education of a/e disciplines with the profiles in X, Y and Z generation students and graduates from Turkey.

Definitions

Generation X, Y, and Z

The rapid changes in the last century have led to the emergence of intergenerational differences (McCrindle & Wolfinger, 2009). Despite the country, level of the economy, openness, technological development, and many other factors differ for each person; mainly social, cultural and economic developments have caused each generation to have diversifying perceptions and expectations (Angeline, 2011). In this section, the characteristics of X, Y, and Z generations will be discussed and the changes in a/e education will be examined as a result of the research model.

Generation X is the generation of individuals born between 1965 and 1979 (Castellano, 2014) which is called “the transition period children” of Turkey. Like the previous two generations (The silent generation (1925–1945) and the baby boom generation (1946–1964)), this generation has faced economic problems (i.e. oil crises). They show the common characteristics of austerity, high job motivation, industriousness, loyalty and respect for authority (Goksel & Gunes, 2017). Moreover, they have waited for an opportunity for a better future and therefore, started to use technology as a necessity because of the technological revolution (Senbir, 2004). Zemke, Raines, and Filipczak (1999) argued that the core values of this generation are optimism, personal development in education and health, commitment to authority and diligence.

Generation Y is also called the post-80 generation (Castellano, 2014). The members of this group grew up in a protective and safe environment created by their families resulted in their transition to become self-centered individuals (Cemberci, Sudak, Asci, Oz, & Civelek, 2014). Generation Y strongly emphasizes characteristics of conducting research, questioning authority, using technology, multi-tasking and communicating with the world. They care about entrepreneurship, open-mindedness, socialization and success above peers but present impatience as a feature at the same time (Arslan & Baycan, 2018; Toruntay, 2011; Yelkikalan, Akatay, & Altın, 2010). This community is technology-friendly, self-centered and more relaxed than previous generations (Senbir, 2004). Their requests for flexible working hours and a comfortable working environment resulting in the design of new studying/working space types.

Generation Z or "Instant Online" generation identifies the individuals born after 2000 (Levickaite, 2010). This community is called the new Silent Generation (Howe & Strauss, 1992) because members of this community will experience individualization and isolation in real life where their virtual relationships may be stronger. Their ability to communicate via virtual platforms prone to lonelier, self-centered and self-conscious lifestyles compared to previous generations. Since generation Z students grow up by solving standardized tests, more attention can be paid to improving their creativity (Moore & Frazier, 2017). This generation may be able to develop their intellectual abilities and research skills quicker than the previous generations due to easier access to a variety of knowledge resources (Akdemir & Konakay, 2014, 2015). Alvarez (2016) advocated that mobility and training are continuous through their career development and they possess a flexible mind capable of organizing and transmitting the information. According to a study from Northeastern University (2014), over 2/3rd of the generation Z students claim to design their own college major and give priority to the entrepreneurship. Oz (2015) and Singh (2014) featured the characteristics of these three generations given in Table 1.

Today, due to the shorter periods of knowledge doubling curves promulgated by Buckminster Fuller, and as a result of construction industry skills becoming technology-oriented, researchers study on the IT to support educational purposes (Heinecke, Milman, Washington, & Blasi, 2001; Wang, Wu, Wang, Chi, & Wang, 2018; Wong, Wong, & Nadeem, 2011). In response to the different demands of the new generations, teaching programs are found insufficient, which suggests that educational environments and programs need to be updated (Somyurek, 2014). The technology-

Table 1 Characteristics of X, Y, and Z generations (Oz, 2015; Singh, 2014)

Generation X	Generation Y	Generation Z
Sensitive and respectful to authority	Devoted to their independence	An integrated life with technology
Develop a sense of belonging to the workplace	Like to spend time individually	Don't have a sense of belonging to the workplace
Realistic	Familiar with technology	Doesn't like to spend time outdoors
Use technology as a necessity	Multiprocessing abilities	Creative
Shopping enthusiast	Impatient	Love being alone
Work to live	Attach Importance to Status	Conscious and confident of their aims

oriented life of the generations Y and Z creates the demand for more interactive and technology-based education in a/e compared to the previous generations.

Education and Technology in Architecture and Engineering

Education in a/e is a multidisciplinary system that focuses on both design and calculation to create a genuine environment that is evolving and changing by the motion of emerging technologies. The graduates after 2020 related to the construction industry are expected to possess high ethical standards, strong analytical skills, practical ingenuity, creativity, good management and communication skills, adaptation to new situations and continuous development (National Academy of Engineering, U. S, 2004) and contribute to society (Pitra, 1992).

IT is an innovative agent that enables new and different alternatives (Ahmad, Russell, & Abou-Zeid, 1995) to organize and operate educational curriculums. In this study, these emerging technologies or innovations covering Computer-Aided Design (CAD) related software systems, project scheduling, operation, budgeting, inspection, maintenance-related software systems or even the presentation related tools in the classes are defined as IT-related developments. It is both related to the technology used by educators in the educational process and the technology used by students through the courses to comprehensively cover the overall student perception.

Even though there were private schools or studios in Italy, the national government of France was the first government that has supported schools to foster architecture as a branch of fine arts in the seventeenth century (Cret, 1941). The formal education in architecture has started with Beaux-Arts in the nineteenth century and the most radical change is experienced with the Bauhaus education established by W. Gropius (Lokce, 2002). In Turkey, Mimar Sinan Fine Arts University was the first institution of art and architecture education established in 1883 (MSGSU, 2020). IT was introduced in architecture in the 1960s, but the introduction of these technologies to architecture education has extended to the 1980s (Rzazede, 2018).

The first engineering university that has a civil engineering department is established in 1707 in the Czech Republic (Czech Technical University) (Vyas, 2018). After the establishment of Istanbul Technical University (ITU) to give education on naval engineering to Ottoman soldiers, the first civil engineering faculty is established in 1795 in ITU for Turkey (ITU, 2019). In the Turkish civil engineering curriculum, IT-related education is initiated with the first lectures of “Electronic Calculation” in ITU Civil Engineering faculty by Ozmen in 1968. Later in 1971, Citipitioglu started giving a lecture named “Computer Methods in Civil Engineering” at Middle East Technical University (Ozmen, 2011).

Under the influence of the aforementioned developments, computer-aided design, energy conservation, and sustainability-related software, as well as Building Information Modelling (BIM), has started to become prevalent in the a/e curriculums. The interdisciplinary work between students from several branches will become more likely to understand the perspectives of different disciplines in the future. In this respect, BIM has exhibited a prominent role in picturing the collaboration of the a/e disciplines. The system covers nearly the whole process of a project such as design, 3D modeling, scheduling, resource management, construction and maintenance (Ofluoglu, 2016).

BIM workshops are established in various universities worldwide; the University of Illinois, University of Florida, University of Kent State, University of Salford and Sydney University that led students from different undergraduate programs to study jointly. One similar workshop is also held in Turkey with a competition called "Design Together" (Alkawi, 2016). In the country, BIM-related education opportunities are still limited in undergraduate education to some prominent public universities such as ITU, METU, and Bogazici University and some private universities in pursuit of innovation. In the recent decade, the number of BIM education opportunities have been proliferated to other provincial districts of the country with private courses. In general, BIM-related courses could be summarized as BIM Expert certificate programs and the education of applied BIM processes in construction projects.

Through these pieces of training, a/e students were able to experience computer-aided modeling. Today, even though an average civil engineering/architecture syllabus in Turkey is not up-to-date as it is desired (Koknel, 2017), innovative lectures are initiated such as 3D modeling, creating animations, virtual reality, and parametric design applications. The development of interactive education has also facilitated interdisciplinary work, which enables correlating different points of view in a single projector. Lately, a/e students emphasized greater importance in understanding project management with different disciplines by taking advantage of technology (Ofluoglu, 2017). Upcoming needs and growing project sizes in the construction sector necessitate different disciplines to work together in harmony (Ozturk, 2018). The number of programs that enable students to establish relations between forms and the mathematical/geometric transformations of these forms (parametric design) has increased. For example, Rhinoceros is a Nurbs-based CAD software designed for 3D modeling and prototyping which enables information exchange between different software; such as Grasshopper incorporation into the Rhinoceros program which enables algorithmic modeling by using modeling tools. Since the operations used in Grasshopper are mathematical, the interface of Rhinoceros is used to visualize the changes (Aydin & Yaman, 2015). However, it should be noted that these programs used in a/e education converts the processes with diversified and arguably easier interactions in education but do not produce the whole design content. The developments in technology also provide variety to students' perceptions and experiences; multi-sensory and interactive education techniques and materials addressing different sensory organs ensure the learning rather than only visual and verbal communication (Madi, 2011).

Literature review

Education in generations X, Y, and Z

In this section, literature research on the educational differences of generations X, Y, and Z is compiled. Moreover, research conducted from different countries is summarized to comparatively understand the Turkish case.

The Portuguese study from Lisboa and Coutinho (2012) stated the obstacles faced in the rapid developments in technology and social changes that emerged in different generations. Different generations with different characteristics sharing the same spaces expose deficiencies in terms of education. This situation also enforces different generations with various characteristics to accept an alike curriculum together. The

authors stressed the necessity of implementing different strategies in education and training for different generations. On the other hand, the Slovakian study on the use of new communication technologies by generations X, Y and Z did not find major differences between the choices of these groups. However, authors emphasized the importance of skills such as communication, technical literacy, learning ability and creativity for the fourth industrial revolution (Grenčíková & Vojtovič, 2017).

The Brazilian study by Barreiro and Bozutti (2017) put forward the inadequacy of lecturers on implementing learning circles, which includes steps of real experience, observation and reflections, development of ideas, and testing. Authors also suggested implementing a problem-based learning method to suit the characteristics of generation Z. Moore and Frazier (2017) emphasized flipped classroom technique which is used as an online record of the lecture to satisfy the independence desire of Generation Z. Also, faculties are said to be responsible for introducing research tools, library databases and the process of peer review. Moreover, academics are being advised to use social platforms to attract their student's attention (Sternberg, 2012). Puiu's (2017) study in Romania found out that generation Z prefers solving exercises, case studies, small-team work, online sources and simulations, and repelled by tests and homework. This study supports Finland's educational model of stimulating creativity and removing homework. Nearly half of the Romanian generation Z want to be managers (45%) and opportunities for development and promotion are crucial in their job preference.

According to an infographic report by Marketo (2014), generation Z knows how to self-train and access information. In the US, 33% of the Z generation follows lessons online, 20% read lessons from the tablet, 32% work online with classmates and 52% use social media for research. However, one interesting statistic from this study revealed that the average time of attention for a cohort in generation Z is only 8 s. According to the research, generation Y prefers to communicate with written text and sharing while generation Z prefers visual communication and creating. Strauss and Howe (1991) put forward that generation Z students would prefer to be personal and independent in group work. In addition to that, this generation is integrated the concept of entrepreneurship for high school and university curricula. Since they are thought to be more easily adaptable to high technology, they are expected to be more percipient but easily get bored workers in the future.

In Turkish studies, Koknel (2017) emphasized the importance of the difference created by the cultural environment of the students to establish the content of curriculum programs and emphasized the characteristics of X, Y and Z generations. It has been indicated that the majority of generation Y tends to live abroad where 20% has been graduated from higher education. The author advises that education of previous generations should be translated carefully according to the age, intelligence, perception and memory skills of students from generation Z. Just like in Aristotle's masterpiece, Politics, he argued that the age, intelligence, perception, and memory of the students who would receive education for successful learning theories should be taken into consideration in translating the curriculum of X and Y generations (Koknel, 2017). Also, Seymen (2017) examined the characteristics of Y and Z generations and mentioned that no significant updates were amended in the 2014–2019 strategy report published by the Ministry of National Education and TUBITAK Vision 2023 report. Seymen stressed that research on the next generations should be carried out and education should be adapted to the changing needs. Cetin

and Karalar (2016) discussed the notion of a career with 1875 students from Edirne and Istanbul. According to the research, Generation Z has a higher tendency towards values, physical mobility, and self-management than others. Protean and unbounded career perception is outweighing for generation Y students.

Education and Technology in Architecture and Engineering

The construction industry needs an integrative education system by virtue of its project-based nature. A literature survey was conducted to investigate the effects of developments in IT on a/e education in this section.

Virtual platforms, discussion forums, and educational games improved creativity, learning process and risk-taking attitude in engineering students of Deakin University. Immersion, engagement, risk, and agency are found as the key elements of successful IT-based educational implementation (Blashki, Nichol, Jia, & Prompramote, 2007). Hanna and Barber (2001) experimented with the computer skills effect on the architecture where 15 students were in the control group and 15 students were trained in CAD software programs for 7 days. After the software education, the developments in concept building, visual quality, and presentation techniques were recorded as positively improved for the trained group. Computer-based tests improved student success since engineering students consider their computer ability has a positive effect on self-efficacy (Hutchison, Follman, Sumpter, & Bodner, 2006). On one hand, interactivity and feedback features of web-based studies and software outperformed pen and paper, on the other hand, pen and paper templates are found effective in idea generation and concentrate on one concept at a time (Valentine, Belski, & Hamilton, 2017).

Chowdhury and Alam (2012) discussed the insufficiency of engineering education in Bangladesh and advised to increase BSc engineering intake numbers by at least six times. Also, similar research about engineering education is conducted for different countries like Ireland (McGrath, 1992), Italy (Zich, 1993), Latvia (Valtere, 1996), Russia (Pukharenko, Vladimirovna Norina, & Aleksandrovich Norin, 2017) and South Africa (Kloot & Rouvrais, 2017) to evaluate the current engineering education and standardization processes. Borri, Guberti, and Maffioli (2005) evaluated the Erasmus networks through accreditation, quality assurance, students' involvement in Engineering Education and Information communication technology and put forward European engineering education systems in terms of international mobility compared to American education (Borri, Guberti, & Melsa, 2007). Benedetto et al. (2010) evaluated the successful joint initiative of two Italian universities Politecnico di Milano and Politecnico di Torino promoting academic coordination. A clearer focus on the context, application of technology, project-based-learning and closer relationships with society attracted engineering education both for male and especially female Danish participants (Du & Kolmos, 2009). Moreover, Kolmos, Mejlgaard, Haase, and Holgaard (2013) found out that intrinsic, financial and parental motivation and social good is more important for male participants, where mentor motivation is more important for female respondents in Denmark. According to a questionnaire of over 4200 engineering students from Germany, a safe job, good career prospects, many contacts, and work-life balance are dramatically unsatisfactory for engineers' ideal and technical job descriptions (Becker, 2010).

"Introduction to Engineering" course in the Brazilian study of Romero, Leite, Mantovani, Lanfredi, and Martins-Filho (2011) introduced the engineering majors through "TryEngineering" website and used conceive, design, implement and operate (CDIO) framework which was established by distinguished universities of Sweden and the U.S. High-school children heavily (88%) found this lecture useful for their career planning. Similarly, the CDIO framework is the third person's theoretical and second person's practical and cognitive collaboration used by the civil engineering program at the University of Limerick, Ireland (Cosgrove & O'Reilly, 2020). Entrepreneurial activities have improved both the retention skills and GPA's of engineering students (Ohland, Frillman, Zhang, Brawner, & Miller III, 2004). The concept maps graphically representing the lecture help students to make stronger connections with the class (Ellis, Rudnitsky, & Silverstein, 2004). Schermer (2001) asserted the efficiency of client-based architectural education because of its social and cultural contribution to expertise. The different scenarios of undertaking the roles of primary design or third-party consultant and client representative would give the necessary skills of working with collaborative teams, strict schedules and real-client based design problems. Angelides and Loukogeorgaki (2005) proposed a framework for the future of civil engineering education by integrating participants from academics, industry professionals, designers, government officials and students discussing worldwide trends, the societal and qualification requirements for European civil engineering education.

Hardin et al. (2016) suggested using team-building and case-based learning to enhance sustainability education by creating partnerships with different parties. The online availability of the sustainability professionals, scholars and researchers, as well as faculty members for students to compete for different levels of prize money substantially increased the competence of the sustainability education quality. Sustainability education in architecture needs to be historically supported, flexible and dynamic. Moreover, rethinking the paradigms by meta-framework give chance for better interaction of layers in the design studios (Khan, Vandevyvere, & Allacker, 2013).

In Turkish studies, Guney (2015) studied on the benefits and disadvantages of IT for architecture education. The advantages are arranged as; alternative design creation, easy storage, and sharing, easier communication with other disciplines, ease of revisions, faster design stages, 3D visualization, time-saving features, a better understanding of design, evaluation, and ease of replication. The disadvantages are aligned as; higher quality visuals instead of better design, less interaction between students and teachers, inadequate literature research, low-quality design, the negative effects of CAD programs on creativity and technology dependence. Gul et al. (2013) investigated the importance of the models and the IT technologies used in architecture education. It is understood that approximately 45% in the curriculum of architecture schools in Turkey is intended for design-related lectures in which students predominantly use AutoCAD software. While 30% of the faculty members certify that IT technologies should be used in architecture, 35% disagreed with this view and 35% remained impartial. But only 61% of lecturers voted for IT to be used in presentation techniques. 70% of the students were not satisfied with the computer-aided design courses they received and 74% of them argued that the lectures contributed to their development of 3D thinking skills through the use of IT technologies at the university.

Mertol and Yılmaz (2011) argued that civil engineering education should be updated with developments in technology and Moran's active learning techniques (Moran,

1997). Moran gathered these techniques under 21 categories covering various narrating techniques, group studies, hands-on training, and multimedia use. So, Mertol and Yılmaz (2011) expected that the digitalization related advancements may become more pervasive with the well-trained teaching staff that will increase the interest in classes and eases the remembering process for students. Ozmen's study (Ozmen, 2011) counseled teaching the basics of programs such as AutoCAD in civil engineering education. Nevertheless, he is concerned that the courses in which vocational software programs thought are not efficient and effective for undergraduate students, where the general public perception of the brilliant results from computer-related education is not indisputably accurate. The author stated that these software-oriented courses should be given at the master's level in detail. Birinci and Koc (2007) argued that civil engineering education should be updated in Turkey because of the constraints about equal education quality between Turkish universities and that the variety of education techniques is not able to compete with developed countries. Oppose to Ozmen's (2011) arguments, they argued that students should be able to solve simple problems with their own programming skills at the bachelor level which is corroborated in today's education system.

Sevindik and Akpinar (2007) expressed the limits of a positivistic educational paradigm about risk-taking, creativity, and entrepreneurship of students. Therefore, the postmodernism paradigm is suitable and it advocates the importance of interaction in the class and creativity. The instructor is more a guide to facilitate learning rather than the authority of knowledge. Most of the students (71%) in Turkey find instructors are insufficient pedagogically and engineering education focuses on mental development ignoring emotions and characteristics of cohorts. Pektas and Erkip (2006) surveyed to discover the male and female differences in the use of IT technologies in architecture education with interior architecture undergraduates of Bilkent University. According to the results, male students were statistically significantly eager to use computers in design, where female students were less enthusiastic. Female respondents are found to be more reliant on the instructors just like Kolmos et al. (2013), however, there were no substantial correlations between both female and male students' attitudes toward computer usage in design and their perception of the instructors' attitude.

In this context, it can be concluded that IT and CAD have different effects on different groups in the literature. The common point emphasized in the studies is that while designing and implementing curriculum, student and generation backgrounds, capacities and future expectations should be carefully considered.

Methodology

In this section, respondents from 5 metropolitan regions of Turkey; Istanbul, Sakarya, Bursa, Antalya, and Eskisehir who are the undergraduates and graduates of architecture and civil engineering majors have been evaluated in terms of their perspective on the technology in education. Throughout the study, several evaluations are conducted with different cohort groups to differ and acquire relevant information.

Sampling process and preliminary study

The most crowded group of the sample is the students from generation Y who lives in Istanbul. The architecture students were mainly from Istanbul and Eskisehir, and

engineering students were mainly from Sakarya. As a sampling method, the voluntary sampling method was chosen where the questionnaire is answered by the volunteers. A total of 29 questions were asked in the survey answered by 160 people. Before the final version of the survey was established, pilot interviews with the three respondents belonging to X, Y and Z generation showed that the survey is clear with its statements and the connections between IT and education are relevant and apprehensible. Moreover, suggestions are accumulated during the questionnaire to improve the survey for future studies. The respondent profile may be followed in Table 2.

Data collection and analysis tool

The research was carried out through a comprehensive data collection process. This study, which was created by combining qualitative and quantitative data, was prepared to analyze the current state of education and how the technology concept in a/e education in Turkey has changed for generations. A total of 400 online surveys were sent out and received in April 2019. At the end of the survey closure, 160 valid responses were collected which represents a response rate of 40%. The questionnaire was used as a data collection tool and the questionnaires were sent to the participants via online forms. These questionnaires were prepared according to the Likert scale (1–5) and analyzed using SPSS 25.0. The survey starts with questions that include general information such as the date of birth, gender, educational status, profession, monthly earnings and questions to measure the interaction frequency of the participants with the internet. Then the participants were asked about the addressed senses, the use of technology frequency in lectures, computer-aided design courses, and tools, knowledge level of new technologies and the future of technology in these educations.

The values of generation type, monthly salary, internet use per day, membership to social media platforms, time spent on social media, satisfactory level of education, satisfied respondents with information technology courses at school, respondents with craft education, number of group studies in bachelors, and remaining Likert questions are tested with skewness and kurtosis, where values are remained in between ±1,5 (Tabachnick, Fidell, & Ullman, 2007) representing the adequacy for statistical consistency. Also, Kolmogorov-Smirnov tests are performed where results were found satisfactory according to Lilliefors (Lilliefors, 1967) to comprehend normality. Therefore, by these tests, our data is classified as normally distributed to enable parametric tests. As there are more than two generations, or by other words, more than two groups to compare, instead of t-tests, ANOVA tests are conducted. After the conformation of homogeneity of variances, which is bigger than 0,05 (Field, 2013; IBM, 2011), one-way ANOVA's posthoc tests are applied to specify the differences between groups. Moreover, when the homogeneity tests are over 0,05, Tukey and Scheffe tests are applied. If the homogeneity value is below 0,05, then Games-Howell tests are conducted (IBM, 2011).

Results

The interest in following IT developments in the a/e education is found crucial. The majority of the group (95,6%) advocated IT is very important (72,5%) and important (23,1%) could be translated to the demand for new IT developments being constantly followed and integrated into the curriculum. The analysis of the survey data revealed

Table 2 Profile of Respondents

Respondents	Sub-Group	n	%	Number of Respondents According to the Generations		
Generation	1965–1980 (X)	20	12,5			
	1980–1999 (Y)	109	68,1			
	2000 - Today (Z)	31	19,4	X	Y	Z
Sex	Female	78	48,8	11	56	11
	Male	82	51,2	9	53	20
Occupation	Student	123	76,9	2	91	30
	Employee	27	16,9	16	10	1
	Student and Employee	10	6,3	2	8	0
If student, the level of studies	1st Class (1)	28	17,5	0	0	28
(Mean = 2,8813; Median = 3; St. Dev. = 1,98222)	2nd Class (2)	7	4,4	0	7	0
	3rd Class (3)	36	22,5	0	36	0
	4th Class (4)	33	20,6	2	29	2
	Extension Student (5)	10	6,3	0	10	0
	Master Student (6)	18	11,3	2	16	0
	Ph.D. Student (7)	3	1,9	1	2	0
Monthly income (Total of scholarships and pocket money for students)	0-500TL (%15 tax bands) (1)	34	21,3	1	22	11
	500–1000 TL (%15 tax bands) (2)	38	23,8	0	25	13
	1000-1500TL (%15 tax bands) (3)	24	15,0	0	20	4
(Mean = 3,2563; Median = 3; St. Dev. = 1,87418)	1500-2000TL (%20 tax bands) (4)	17	10,6	2	13	2
	2000-3333TL (%20 tax bands) (5)	16	10,0	1	14	1
	3333-12333TL (%27 tax bands) (6)	26	16,3	11	15	0
	12,333- over (%35 tax bands) (7)	5	3,1	5	0	0
Internet usage per day on tablet, mobile and PC	Less Than 1 h (1)	6	3,8	0	5	1
	1–3 h (2)	68	42,5	15	34	19
(Mean = 2,6875; Median = 3; St. Dev. = 0,81794)	3–5 h (3)	56	35,0	2	44	10
	More than 5 h(4)	30	18,8	3	26	1
Use of social media (Facebook / Instagram / Twitter)	I dont use social media platforms (1)	8	5,0	1	5	2
	I'm using one platform (2)	50	31,3	5	33	12
(Mean = 2,8375; Median = 3; St. Dev. = 0,86065)	I'm using two platform (3)	62	38,8	9	38	15

Table 2 Profile of Respondents *(Continued)*

Respondents	Sub-Group	n	%	Number of Respondents According to the Generations		
Generation	1965–1980 (X)	20	12,5			
	1980–1999 (Y)	109	68,1			
	2000 - Today (Z)	31	19,4	X	Y	Z
	I'm using three platform (4)	40	25,0	5	33	2
Hours per day spent on social media	I dont use social media platforms (0)	8	5	1	6	1
	0–1 h (1)	45	28,1	8	26	11
(Mean = 2,9063; Median = 3; St. Dev. = 0,96346)	1–3 h (2)	72	45	9	46	17
	3–5 h (3)	26	16,3	1	23	2
	5–7 h (4)	7	4,4	1	6	0
	More than 7 h (5)	2	1,3	0	2	0
Tracking techological developments in Education	Yes	101	63,1	11	70	20
	No	59	36,9	9	39	11

that the mean value of the satisfaction from a/e education is 3,13 (average) and the standard deviation is 1029 where "Moderately-I am familiar with my profession thanks to my education" answer was the most common answer. IT-related courses are mostly found unsatisfactory (67%) where over 81% of respondents are taken computer-aided design lectures. Over 58% of respondents prefer both traditional and computer-aided design solutions for design courses. The remaining statistics may be followed by Table 3.

Moreover, problem-solving abilities are the prominent feature found to completely comprehend the education for a/e that may be followed from the Fig. 1, below. Generation Z has shown greater importance on design, creativity, and imagination as well as problem-solving capabilities in education than the previous generations. The result of lower knowledge levels of newer technologies in the industry like BIM may be associated with the age of generation Z who are still young and mostly in the first year of their bachelor's.

It is important to differ the education satisfaction and knowledge levels of IT between a/e students. Architectural students are more satisfied with their overall education but the IT courses, as opposed to engineering students. Computer-aided courses are involved in the curriculum for both professions. The most striking weakness was BIM education; nearly 3/4th of engineering students and more than half of the architectural students did not have an idea about BIM. Sustainability related education should be improved especially for the architects of the future. The remaining statistical comparison of Architecture and Engineering students related to IT in education could be followed in Table 4.

Apart from this comparison, t-tests are applied for the a/e students. In the study, while public universities have more than 20 years of experience, private universities

Table 3 Answers of Respondents According to Generations

Answers	Sub-Group	n	%	Mean	Mean X	Mean Y	Mean Z
Satisfactory level of overall education	Insufficient (1)	10	6,3	3,131	4,150	3,028	2,839
	Less than enough (2)	31	19,4				
	Moderately (3)	61	38,1				
	Sufficient (4)	44	27,5				
	Very Sufficient (5)	14	8,8				
Satisfactory level of courses related to IT	Satisfied (1)	36	22,5	2,194	2,350	2,239	1,935
	Neutral (2)	67	41,9				
	Not Satisfied (3)	57	35,6				
IT Development used in Lectures (Frequency)	Never (1)	8	5,0	3,200	2,650	3,367	2,968
	Rarely / Around 10% (2)	39	24,4				
	Sometimes / Around 50% (3)	43	26,9				
	Frequently / Around 75% (4)	53	33,1				
	Always (5)	17	10,6				
Computer Aided Design Courses	Taken (1)	130	81,3	1,188	1,450	1,092	1,355
	Not Taken (2)	30	18,8				
Design Tools for Design Classes	AutoCAD / Revit etc. software	30	18,8	2,400	2,350	2,523	2,000
	Traditional methods (Paper/ pencil)	36	22,5				
	Both	94	58,8				

have been established relatively recently. Engineering students who study at public universities and private universities have a statistically significant difference in a satisfactory level of their education; public universities have higher satisfaction levels. Conversely, architecture students who are studying in private universities have a higher percentage of courses benefitted from IT than public university students. Consequently, even though the IT usage level is higher in private universities, the efficiency of related education is not satisfactory.

According to the sense related questions, generation X and Y have responded that vision is superior to other senses, however, generation Z has identified similar and even greater importance on hearing. Architectural movements have not yet affected generation Z due to the lack of information and callowness. Modernism and sustainability are found as the prominent movements for the respondents on average. The remaining statistics regarding the average results of generations may be followed by Fig. 2.

It is the generation Z that agrees the most that technology will guide a/e education in the future, where generation X is more conventional with this insight which suits the

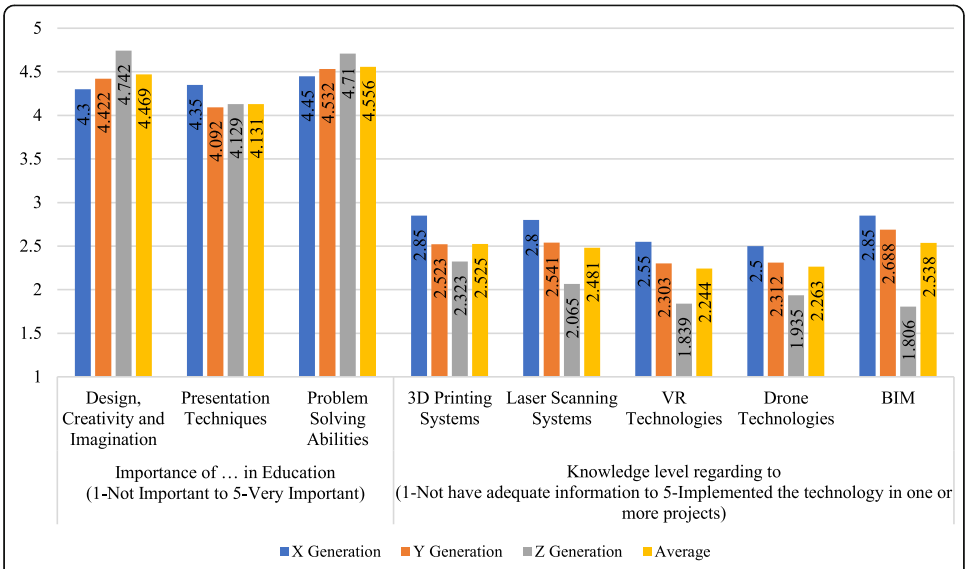

Fig. 1 Importance and Knowledge Level of Some Techniques/Technologies According to Generations

characteristics mentioned by Oz (2015). Also, related to the upcoming strengths of computer-aided design such as the elimination of the human factor is mostly appreciated by generation Z, given in Table 5.

According to Table 6, generation X have statistically more affected by the postmodernism movement and more satisfied with their education than generations Y and Z. Generation Y is the least satisfied group with the level of courses related to IT. Generation Z claimed that they have more study opportunities in a multidisciplinary team in

Table 4 Architecture and Engineering Students Opinion Related to IT in Education

Question	(Yes = Experienced, No = Not Exp.)	Architect (%)	Engineer (%)
Sufficiency of the Education	Insufficient (1)	7,1	6,5
	Less than enough (2)	21,4	32,3
	Moderately (3)	36,9	35,5
	Sufficient (4)	29,8	19,4
	Very Sufficient (5)	4,8	6,5
Satisfaction from IT Courses	Satisfied (1)	19,0	35,5
	Neutral (2)	38,1	25,8
	Not Satisfied (3)	42,9	38,7
Multidisciplinary Study	Yes (1)	50,0	41,9
	No (2)	50,0	58,1
BIM Education	Yes (1)	46,4	25,8
	No (2)	53,6	74,2
Sustainability Education	Yes (1)	57,1	67,7
	No (2)	42,9	32,3
Computer-Aided Courses	Yes (1)	83,3	93,5
	No (2)	16,7	6,5
Tools used at the Design courses	AutoCAD / Revit etc. software	17,9	32,3
	Traditional methods (Paper/pencil)	25,0	6,5
	Both	57,1	61,3

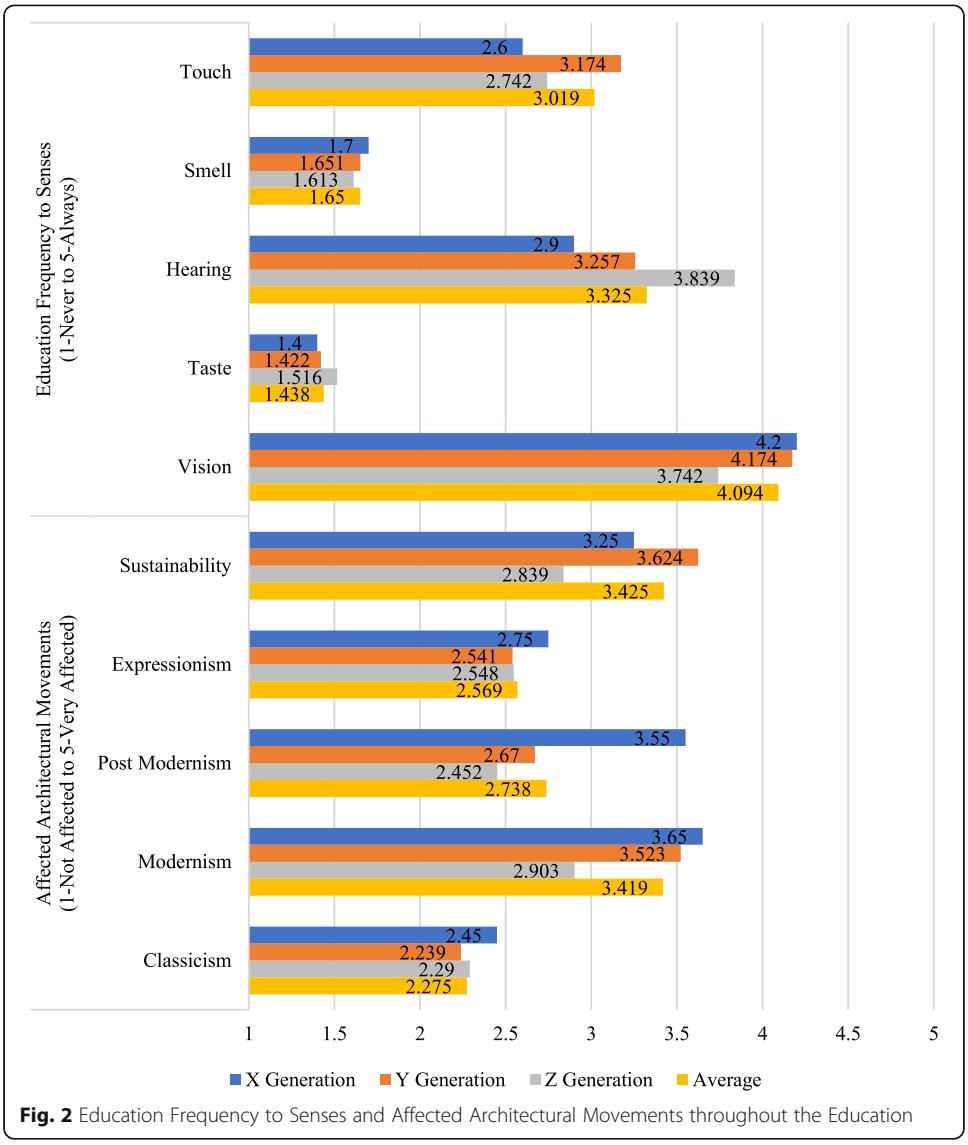

Fig. 2 Education Frequency to Senses and Affected Architectural Movements throughout the Education

Table 5 Technology and Education Related Expectations of Generations

Question / Generation		X	Percent.	Y	Percent.	Z	Percent.
Technological developments will lead future of a/e education	Yes (1)	18	90,00%	104	95,41%	31	100,00%
	No (2)	2	10,00%	5	4,59%	0	0,00%
Computer aided design will eliminate human factor in design	Yes, it will (1)	4	20,00%	29	26,61%	9	29,03%
	No, it will not (2)	5	25,00%	10	9,17%	3	9,68%
	The human factor will always remain, but its share will be reduced (3)	11	55,00%	67	61,47%	18	58,06%
	Don't know (4)	0	0,00%	3	2,75%	1	3,23%

their bachelor studies. Besides the table, respondents with the highest salary levels gave higher importance to both traditional techniques and IT in design courses than the other respondents.

Table 6 is coded to be followed easier and this paragraph aimed to explain this table respectively. The (*) sign at the groups represent the superiority over the compared one. Generation X are more satisfied with their education than newer generations. The satisfactory levels of IT-related courses for the remaining generations are higher than the generation Y. However, generation Y claimed that the IT-related courses are more frequent; where this situation may be explained by different expectations of groups and inefficiency of these courses. The level of knowledge difference between Y and Z may be interpreted with the experience of the industry. Type of lectures is mostly "design" in generation X, where "CAD" lectures are in majority in generation Z. Moreover, generation Z put forward their greater opportunity to study the craft and with other professions than generation X. Also, sustainability-related education is applied more in

Table 6 ANOVA Results (Tukey Tests)

Code	Dependent Variable Explanation	Generations to Compare First	Second	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1A	Satisfactory Level from Education	X*	Y	1,12248*	0, 249	0, 000*	0,502	1,743
1B	Satisfactory Level from Education	X*	Z	1,31129*	0, 291	0, 000*	0,603	2,019
2A	Satisfactory level of courses related to IT	X*	Y	,35826*	0, 117	0, 016*	0,062	0,654
2B	Satisfactory level of courses related to IT	Y	Z*	-,26310*	0, 092	0, 018*	−0,487	−0,039
3	IT Lead Studies (Frequency)	X	Y*	-,71697*	0, 257	0, 016*	− 1,324	−0,110
4	Level of BIM Knowledge	Y*	Z	,88162*	0, 285	0, 007*	0,206	1,557
5	The Type of Lectures (Mostly)	X	Z*	− 1,05806*	0, 330	0, 005*	− 1,838	−0,278
6	Multidisciplinary Study Opportunity in Bachelor	X	Z*	-,39194*	0, 135	0, 017*	−0,722	−0,061
7	Craft Education	X	Z*	-,64677*	0, 166	0, 001*	− 1,053	−0,241
8	Sustainability Education	Y	Z*	-,40722*	0, 089	0, 000*	−0,622	− 0,192
9	Technique Preference in Design Courses	Y*	Z	,52294*	0, 152	0, 003*	0,156	0,889
10	Internet use Per Day	Y*	Z	,48002*	0, 136	0, 002*	0,154	0,806
11	Modernism Movement	Y*	Z	,61971*	0, 261	0, 049*	0,002	1,238
12	Postmodernism Movement	X*	Y	,88028*	0, 299	0, 010*	0,173	1,587
13	Postmodernism Movement	X*	Z	1,09839*	0, 352	0, 006*	0,265	1,932
14	Sustainability Movement	Y*	Z	,78514*	0, 294	0, 028*	0,072	1,498

Represents Significance to Other in the Section of Generations to Compare

generation Z than Y. Because of the freshman year of generation Z, technique preference in the design classes is traditional tools such as hand-drawing, where generation Z preferred both traditional methods and CAD solutions. Internet use was statistically higher for generation Y than Z, but averagely in between 1 to 3 h. Generation Y has greatly affected by modernism and sustainability movement than Z, where generation X has affected by post-modernism than newer generations.

Furthermore, the regression tests are conducted. Therefore, the satisfactory level of education is found to be inversely correlated with the generations. Moreover, the t-test is conducted because of the comparison between sexes. The following Table 7 explains that there are statistically meaningful differences in the given dependent groups. Female respondents gave statistically higher emphasis on each dependent given below. Accordingly, vision-related and interaction-based educational actions are more important for female respondents that support the study of Kolmos et al. (2013), and Du and Kolmos (2009).

Discussion

This study offers clues about a/e education in Turkey. The group that contributed the most to the average values was the students in the generation Y. The respondents heavily emphasized the importance of following IT developments in the a/e education and updating information/methods continuously. Generation Z has a stronger belief in the IT movement that will guide the a/e education in the future relatable to their instant-online lifestyle (Levickaite, 2010).

Problem-solving abilities have been found as the most important impact of a/e education in generations X and Y, where generation Z gave priority to design, creativity, and imagination. As, generation Z prefers visual communication and creating (Marketo, 2014), standardized tests hindering creativity may be precluded (Moore & Frazier, 2017). The new curriculum may prioritize visuality and creativity by giving more importance to the project or case-based education of software programs (Hardin et al.,

Table 7 Independent Sample t-test Results

Dependent	Group 1	Group 2		Levene's Test		Sig. (2-tailed)
				F	Sig	
Education Applied to Sense of Vision	Female*	Male	Eq. var. as.	2,148	0,145	0,001*
			Eq. var. not as.			0,001
The effect of Modernism Movement	Female*	Male	Eq. var. as.	3,172	0,077	0,001*
			Eq. var. not as.			0,001
The effect of Postmodernism Movement	Female*	Male	Eq. var. as.	0,835	0,362	0,028*
			Eq. var. not as.			0,028
Importance of Presentation Techniques in Education	Female*	Male	Eq. var. as.	3,589	0,06	0,004*
			Eq. var. not as.			0,004
Usefulness of Computer Aided Software in Design Courses	Female*	Male	Eq. var. as.	38,6	0	0,001*
			Eq. var. not as.			0,001

Represents Significance to Other Gender

2016) and related scenario analysis (Schermer, 2001) that helps students to visualize the changes (Aydin & Yaman, 2015). The reason why architectural students are more satisfied with their overall education may be related to the visual-themed education model with more opportunity to work multidisciplinary. Therefore, engineering education with multidisciplinary teams is to be encouraged which seems already changing with generation Z claimed they have more multidisciplinary study opportunities. CAD education is widespread for a/e students. However, the knowledge levels of BIM low for both a/e students and IT-related satisfaction is at 19% for the architectural students. To raise the satisfaction levels from IT courses, project management basics (Ofluoglu, 2017) of the aimed time, cost and quality constraints with 3D modeling may be emphasized instead of only sketching curves of 2D plans that have been used by previous generations (Guney, 2015; Ofluoglu, 2016). The levels of sustainability-related education are found partial especially for architectural students. A dynamic, flexible, historically supported sustainability curriculum with project-based team-building opportunities and continuous communication with the sustainability professionals is the way for students to absorb the information (Hardin et al., 2016; Khan et al., 2013). Even though generation Y claimed to be affected by the sustainability movement, generation Z presented a better understanding of sustainability, which represents the proliferation of veridical information in the future.

Unlike generations X and Y, generation Z gave priority to both vision and hearing sense. This supports Moore and Frazier's (2017) flipped classroom technique emphasizing the importance of educational videos. By this, the freedom and time/space flexibility demanded from the generation Z can be supplied. Moreover, it will be much easier to solve the issue previously mentioned by Birinci and Koc (2007); achieving equality in access to education. Generation Y is the least satisfied group with the IT-related courses, which may be associated with the lack of educational opportunities. Today, thanks to the pervasion of educational or software related videos, information is easier to reach especially for the generation Y users who claimed to spend more time on the internet (1–3 h/day) than generation Z. Because of the outdated education techniques and the mismatch between IT-related features of employment opportunities and the current education system, satisfactory levels of education have been found the least for the generation Z. Generation X is more satisfied with their education and statistically more affected by the postmodernism movement and design courses. This result supports the study of Sevindik and Akpinar (2007) about the suitability of postmodernism movement to education valuing creativity and instructor's not only authority but guidance to the knowledge (Sternberg, 2012). The greater effect of the education system of the modernism movement may be caused to augment the unsatisfied members of generation Y.

Different curriculums to the generations should be created according to their age, attention, culture, intelligence, perception and memory skills (Koknel, 2017; Lisboa & Coutinho, 2012; Marketo, 2014; Seymen, 2017; Zhou & Teo, 2017). A new curriculum with recent education techniques such as flipped classrooms, highlighting the cooperative and case-based nature of construction, contacting continuously with professionals, giving hands-on applications about the new technology and matching the education to actual business needs may positively affect the posterity. But most importantly, new a/e education should embrace innovation and change.

Conclusions

Means and methods of construction have changed drastically with the technological developments. This change also affects the a/e curriculum. This study explained the literature for the characteristics of generations X, Y and Z while giving information about the technological advancements in a/e curriculum. The results of this study indicated differences between generations and the necessary solutions in the discussion part. Some outputs from the questionnaire are that; generation Z believed the most that technology may guide a/e education in the future and computer-aided design may replace the human factor. Members of Generation Y are the least satisfied with the content of IT-related courses. A/e students from public schools have higher satisfaction levels of education than students from private universities. This result is affected by the unsatisfied private school students from generation Y and Z. Also, satisfactory levels of education found inversely correlated with the newer generations in Turkey. A more productive and efficient system with reducing the working hours may be beneficial just like the examples from Sweden or Finland (Puiu, 2017). Moreover, presenting role models, highlighting the cooperative and problem-solving nature of construction and emphasizing practical work and hands-on implementation strategies rather than drowning in the theory is suggested (Becker, 2010). The outcomes of this study are expected to guide professionals in architecture and engineering education to better address the expectations of upcoming generations in Turkey. However, it should be noted that the outcomes of this study are limited by the number of respondents and their characteristics. Future studies would have a broader perspective for correlations between the facts that have caused the differences and validate the findings in larger and different cohort groups.

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