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Digitally enhancing interior architecture education: Case of online building surveying class

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Abstract
Interior architecture has a key role in the sustainability agenda of the architecture, engineering and construction (AEC) industry, being directly related to adaptive reuse projects. As adaptive reuse projects rely on the analysis of the existing building and its environment, building surveying (BS) has significant importance for the profession. While the BS practice has significantly evolved through the use of new technology encompassing digital photogrammetry, BS education seems lagging behind. Despite the presence of promising computer-assisted learning prototypes for decades, these methods are far from being implemented broadly into the curriculum. However, this reluctance is challenged by the emergency situation caused by the Covid-19 pandemic and the need for new digital teaching methods became apparent. This paper describes the development of a digital practice module for BS education for interior architecture students. In an experimental practice based on action research, interior architecture students are introduced to a digital surveying application. After a brief introduction by an expert, students are directed to research sources and third-party video tutorials. They are asked to collaborate in groups to solve how to use the software application themselves. Following the research period, students completed two sets of practices. Although the research period was kept short, the progress of the students' performance between these two practices, and the results indicate interest in digital practices. The outcomes of the research are promising for implementing digital technologies into the interior architecture department's BS course curriculum.

Keywords
Action research, Digitalization, Information Technology (IT), Innovation, Surveying application.

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1. Introduction

Developments in the Information Technology (IT) domain introduced several technological advancements into the Architecture, Engineering, and Construction (AEC) industry. Various digital tools and equipment became common and accessible, transforming different areas of architecture such as design, planning, practice, and education. Building Surveying (BS) did also take its share. Today, apart from the conventional surveying techniques, electronic leveling and measuring equipment as well as mechanical ones, Geographical Positioning System (GPS) technology, 3D laser scanning and digital photogrammetry are widely used depending on various requirements.

Despite this digitally evolving business environment, evidence of new technology implementation into the BS education in literature is limited. Efforts dating back to the 1990's are present, but such technologies did not show up in our education systems and did not become widely accepted, despite the evolving educational problems and the advancements in IT. The need for adapting new technologies became evident in early 2020, this time because of the emergency caused by the Covid-19 pandemic. Face-to-face classes were canceled, and universities had to turn into an online distance education setup. The biggest challenge appeared for the courses that depend on practice such as design studios and BS courses. Neither instructors nor students did have enough time to get ready for it, but new ways of teaching practices had to be developed in a limited time.

On the other hand, renovations and adaptive reuse projects are common practices of the interior architecture profession. From the sustainability perspective, interior architecture supports AEC industry to upcycle the building stock by demanding interior designers to focus specifically on an already existing building envelope. This 'already existing' state brings the need for proper documentation of the building, thus requires a detailed BS work. Regarding its key position for the profession, BS courses should be given a particular importance in the interior architecture education.

In this context, a digital surveying practice is introduced to the interior architecture fourth semester students, within the BS course program. Considering the challenges of online distance education setup, the practice focused on digital photogrammetry technique, by using a dedicated software and the equipment students already have, using action research methodology. The main aim of this study is to determine the integration of new technology implementations into the online BS education and identify the potential use of such techniques as an online education tool, while exploring the barriers of implementing IT into the conventional surveying education setup. After diagnosing the problem as the first phase of AR, students were asked to apply a digital surveying practice through software that performs photogrammetric processing of digital images and generates 3D spatial data for the creation of digital surveying documents. An online questionnaire was used to gather technical details and to understand the participants' observations as well as other qualitative and quantitative aspects of the case.

The results are promising for developing new educational material and integrating them into the curriculum by taking the IT developments in BS practice into consideration. Moreover, the need for further research on the impact and efficiency of new BS techniques compared to the conventional surveying methods becomes prominent.

2. Theoretical framework

Architects intend to record and identify their observations about a building or space by conducting sketches and diagrams. These are part of survey drawings, operating as both documentation and analysis, enabling an architect to examine certain conditions of the built environment, whether it's geometric, relational, material or technical (Wells, 2021). Surveying is a measurement system made for expressing a three-dimensional (3D) structure with two-dimensional (2D) drawings such as plan, section, elevation, and details (Uluengin, 2016). It also comprises a thorough identification of materials, and structural design, together with social and historical aspects as layers beneath its skin, that has undergone change through its lifespan. In this context, taking measurements is one of the fundamental activities that will affect other components of surveying as well as other stages of architectural work that will be built upon the surveying documents. In order to avoid mistakes, surveying methodology has discrete rules and systematics (Pehlivan et al., 2022). The process is labor intensive and open to human error. Nevertheless, BS techniques are evolving with the effect of technological advancements.

2.1. Technological advancements and digitalization in surveying

The origin of the building measurement systems is based on geodetic surveying techniques with single-point methods used in manual surveying and aerial measurement methods like photogrammetry (Blankenbach, 2018). Photogrammetry is a documentation method (Hamamcıoğlu Turan, 2004) which has a past almost as old as the photography itself.

In contrast with the conventional surveying methods, digital surveying methods are focused on 3D models by creating point cloud data that enables depicting height, distance, coordinates and volume by the use of dedicated computer software (Pehlivan et al., 2022; Vlachos et al., 2019). These software enable creating orthophotos that can be transformed into 2D drawings where needed, as a later stage following the model. Workflow change, brought by these technological advancements, alters the order of conventional drawing process both architecturally and for the BS practice. These technologies reduce the margin of error by making more precise measurements, save time for the surveying work (Benli, 2015), and provide detailed information during the deskwork stage of surveying (Başar et al., 2021). While giving information about the materials and elements used in the building, the damage determination can be made through photographs (Zağra & Özden, 2020).

Today, a moderate smartphone camera offers enough resolution and quality that can be used to capture images to produce low-budget 3D models in surveying studies (Caroti & Piemonte, 2020). Smartphones and tablet computers with integrated Lidar technology, mobile device applications that provide an augmented reality interface for taking measurements and draw floor plans that can be exported in many industry-standard formats are on the market. As these technologies are getting more accessible, new opportunities loom up for further enhancements of architectural education, and in particular, BS courses in the scope of this research.

2.2. Building surveying education

Although it has an established part in architectural heritage research due to preservation by documentation purposes, BS is an important part of contemporary architectural practice for all kinds of adaptive reuse and renovation projects. Especially when interior architecture is considered, dealing with a building that is already present is the nature of the profession in most cases (Coles & House, 2007). Residential buildings are taking the lead in renovation works, while spaces such as bathroom and kitchen are the most studied areas. These spaces are on top of the frequently renovated list (Coles & House, 2007), and make up an important part of renovation costs (Yazıcıoğlu, 2014). With this potential, residential units have a prospective potential to be one of the first professional experiences in students' professional lives. As a result, all this work is related to an existing structure and dependent on thorough surveying documentation. Therefore, BS courses have a significant importance for the interior architecture profession and especially for new graduates.

Site work stage of the surveying practice can be considered as the introduction of the building with all its tangible and intangible assets to the students personally, as the students perceive all the schematic layout, structural design, and used materials as well as its cultural aspects and relation with the surrounding environment. As for the technical aspects of BS requests, much of the surveying work and presentations are performed within groups (Uluengin, 2016). Students are being asked to prefer sketching techniques in order to develop their drawing skills with hand–brain coordination, while having direct contact with the building.

However, the conventional BS methods are not being practiced by the industry without the support of digital technologies. The agenda for integration under Building Information Modeling (BIM) creates new challenges for the future AEC industry with unfortunate outcomes for BS (Blankenbach, 2018). Besides, the labor-intensive character of surveying lacks its answer in education for some time now. Increasing number of students, and reduced staff/student contact time due to institutions transferring resources out of teaching and into research, are being criticized for decades (Mika, 1999), because of restricting such a master-and-student process. New educational programs with digital methods are proposed by many (Shults, 2019), such as the Interactive Survey Information System prototype (Mika, 1991, 1995, 1999) and the building pathology education application by Shelbourn et al., (2000). These were remarkable efforts on digitalizing the BS education based on computer aided learning applications, proposed during the infancy of operating systems with a graphical interface. Their aim was to train building surveyors by enhancing traditional teaching techniques, through simulating a real-life survey experience. These prototypes were developed decades ago in order to avoid foreseen shortages of the higher education system. Nevertheless, none of these justifications have succeeded to start a comprehensive debate on the digitalization of the BS education, until the online education setup that was enforced by the Covid-19 restrictions made it apparent.

2.3. The challenges caused by the online education

Online education requires students to problem solve and learn new skills using the internet, with resources such as online tutorials, lectures, blogs, and social networks. It gives a great flexibility of time and location and resolves many problems related to the physical limitations of a classroom. However, online education is debated to have specific issues for departments that require group work, common working space, and equipment usage (Ceylan et al., 2021), insufficient physical, social, and cultural site analysis practice (Yazıcıoğlu Halu & Kula Say, 2021), and loss of student-student and student-lecturer social and learning interaction (Iranmanesh & Onur, 2021), which is considered as an essential characteristic of studio classes (Ahmad et al., 2020; Yu et al., 2021). Other challenging topics include the level of attraction and performance score differences between genders towards technology-based courses (Demirbas & Demirkan, 2007) and the huge impact of socio-economic factors (Marshalsey, 2021).

However, technology can be adapted to enhance pedagogical frameworks with special emphasis on providing support for personalized, self-directed, and distributed learning, while enabling diverse and innovative communication methods (Hassanpour & Şahin, 2021; Kocatürk et al., 2012). Students of today are considered as digital natives (Kennedy et al., 2008), but the attitude of students towards online learning is largely underexplored, especially for design-oriented departments like architecture (Fleischmann, 2020).

3. Methodology

This research focuses on simulating the site work practice of BS education using digital tools that became difficult to exercise during the online education setup. The research methodology structured under four subtopics is given below.

3.1. Study participants

This research is conducted in the building surveying undergraduate course of interior architecture department, in a state university, in Istanbul, Turkey. The authors were the instructors, and the participants are the active attendees of the building surveying course.

3.2. Action research

Design of this study is collaborative action research (AR) that follows the practical AR principles, which is frequently used in studies related to education. In practical AR, the educator defines the research problem and collaborates with experts where needed (Sáez Bondía & Cortés Gracia, 2021). AR includes a reflective process of inquiry and knowledge generation, to generate new practices (Somekh & Zeichner, 2009). In educational contexts, the reflective process of AR allows to deepen the studied situations and obtain more socially just and productive outcomes (Sáez Bondía & Cortés Gracia, 2021). AR is a five-phase cyclical process (Azhar et al., 2010), consisting of: (1) Diagnosing the problem, (2) Action Planning, (3) Action taking, (4) Observing, analyzing, and evaluating, (5) Reflecting the lessons learnt back into action/intervention.

3.3. Material and instruments

After diagnosing the problem, a digital surveying practice is planned. A dedicated surveying application, Agisoft MetaShape trial version is implemented for creating digital surveying documents. The software is selected with the guidance of a BS expert, who is an interior architect and partner of a digital surveying company. An initial enquiry showed that none of the students had previous experience with the chosen software, which contributes to the objectiveness of the research during the initiation and learning process.

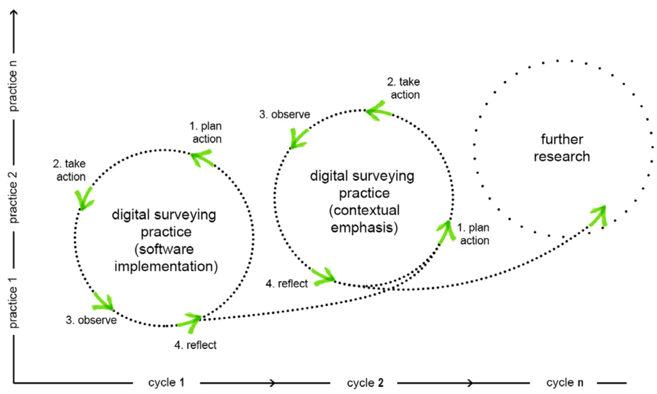

Figure 1. *The cyclical process of AR following problem diagnosis.*

3.4. Data analysis

Following the iterative process of AR, observations are made during the first stage of the practice, and students' feedback is collected during the presentations, trying to identify their preliminary studies for using the software, equipment they used, method of photographic documentation, and their satisfaction, with unstructured and open-ended questions. Additionally, student comments about different phases of the process are noted by the researchers to design and improve the second practice experience. After the second practice, an online questionnaire is used to gather technical details and to understand the participant observations as well as other qualitative and quantitative aspects of the case in a more structured way. The data is obtained by the questionnaire and student submissions form the main sources of evidence for the research. During the data analysis, each student is coded to keep their anonymity in terms of their personal space and remarks about the experience. Microsoft Excel is used for the descriptive parts of the analysis and IBM Statistical Package for Social Sciences (SPSS v27) is used for correlation and variance analysis of the data where needed.

4. Action research process and the results

According to the methodological framework, an online practice of the digital surveying software is implemented in the building surveying undergraduate course of the interior architecture department. Number of students enrolled in the course was 75, but the number of active students fell to 67, as 8 students dropped or did not attend the course.

In accordance with the AR principles, the research started with problem diagnosing as shown in Figure 1.

4.1. Problem diagnosing

The program of the survey class required practices that should be done as a group, and on site. Students were being assigned to conventional tape measure and hand sketch surveying practices in their living environment. However, the health and safety measures taken nationwide during the Covid-19 restrictions transformed the course into an online studio setting, creating a challenge to find new ways to compensate for the fundamental exercises. The online setup lacked the assistance of the instructors during the surveying practice and restricted the instructor-student and student-student interactions. Scanned submissions and deskwork end-products were causing doubts about their originality, and students were signaling knowledge gaps. Executing these tasks appeared as a problem to solve. At that point, the researchers realized that trying to imitate conventional measuring practices were inadequate to compensate for the loss. Instead, it is decided to implement a digital practice that will fit into the course syllabus and help alter the adverse effects of the online class, while improving other skills for BS education. Consequently, this digital surveying study aimed at planning and executing two separate digital surveying tasks, which are labeled as Practice 1 and Practice 2, for fitting into and fulfilling the cyclical process of AR.

4.2. Practice one

4.2.1. Action planning

The first digital surveying practice started with the dissemination of the project brief of the module, during the 11th week of the undergraduate course. The software they will use, technical equipment they need, and the spaces they will survey are released with this brief. The object of their first 3D model is identified as the students' own work environment, where they participate in the online surveying class. To limit the irregularities, two intersecting walls, floor and ceiling partitions intersecting with these walls are asked for their model. A short introduction for the selected software is given by a BS expert. Students are asked to work as a team of five arranged by the instructors, and to complete the installation process themselves by getting help and sharing their newly gained software experience within the group where needed. Additional educational resources are also given with the brief such as the user manual of the software and a third-party YouTube video link that has a step-by-step guide for the software. They are asked to make further research on using the application as required.

4.2.2. Action taking

At this stage, students are asked to take photos of the space as defined in the previous stage and start using the designated software to create their 3D models. Each student had one week to create their room's 3D model and prepare a single group presentation together with their teammates to accomplish this stage.

4.2.3. Observing, analyzing, and evaluating

Before the group presentations, students are asked to give detailed information on their preparation process for using the software, technical specifications of the computer and camera they utilized, photography technique, light sources, and number of photographs they used for creating their 3D models. Moreover, following the presentations, they are asked for their comments on the experience. Their feedback is used to develop the Practice 2.

Demographic data

At this first stage, 47 (39 female, 8 male) out of 67 students presented their 3D models created by using the software. Among them, the course was selected mostly by students who were in their 3rd year of study by 53,2% (N:25). Students who were in their second year of study were 27,7% (N: 13), fourth year by 8,5% (N: 4), fifth year by 6,4% (N: 3), and finally, sixth year by 4,3% (N: 2).

Technical capabilities of the equipment used

One of the first challenges that was critical for the success of this research was whether the students have computer and camera equipment with necessary technical specifications or not. On the computer side, the minimum system requirements expected for the program to run smoothly and the recommended configuration to achieve the best outcomes were compared with the specifications revealed by the students. Considering the suggested configurations, the answers revealed that all the students (N: 47) provided the minimum processor speed requirements and 65,9% of the students (N: 31) used at least the recommended processor specifications. While all the students used at least the minimum Random Access Memory (RAM) size of 4 Gigabytes (GB), the recommended RAM size of 32 GB was nonexistent. However, in compliance with the Metashape User Manual (2021), minimum configuration values were sufficient to create a 3D model based on 30 to 50 photos with a single image resolution of 10 MegaPixels (MP). Moreover, the higher value of RAM used by students was 16 GB, used by 48,9% (N: 23).

In terms of camera specifications, a resolution of 5 MP or above was recommended by the software to provide the most appropriate data for a 3D model. The first practice revealed that 95,7% (N: 45) of the students had a digital camera capable of taking 5 MP pictures or over. The presence of the remaining 4,3% of students (N: 2) are noted for the evaluation of this stage and planning of the next.

Preparation process

Students in the same group are expected to get in touch with each other and share their experiences for installing and using the software. In the assignment sheet given for the group work, three different kinds of documents were suggested as learning resources: Agisoft MetaShape user manual in Portable Document Format (PDF), tutorial videos and third-party YouTube links for the utilization of the software. While 85,1% (N: 40) of the students stated that they read the PDF document partially or as a whole, the number of the students who didn't read the document was 14,9% (N: 7). The number of students who watched the given tutorials were 93,6% (N:44) . The number of students who researched a different resource was 46,8% (N: 22) excluding the online sources given in the brief. It is decided that the students who participated in the group work completed their initial training in Practice 1. Also, students commented on group work as "…a good start to understand the program interface" (S1).

Photography technique, source of light and number of photos used

In the scope of photography techniques to capture the appropriate scenarios, panning and tracking methods are recommended for the camera angle and positioning. Panning is pivoting the camera on a vertical axis, to follow horizontal movement of the subject. However, this is only limited to object motion that is parallel to the image plane. For capturing more complex object motion that is not parallel to the image plane, the camera should move in the 3D space to track the object, which we call a tracking shot. Both methods are defined for a moving object of interest, followed by the camera during a relatively long exposure.

Presentations showed that 48,9% of the students (N: 23) used the panning method, while 40,4% of the students (N: 19) used the tracking method for capturing photographs. 10,6% (N: 5) of the students did not define their photography technique. Most of the students preferred natural light while taking photos by 40,4% (N: 19). Students who used only artificial light sources were 42,5% (N: 20). Moreover, students who used both natural and artificial light for capturing photos were 17% (N: 8).

The number of photos required for reaching best results for a 3D model is not clearly stated in the user's manual as it depends on the spatial dimensions and details of the space the user is dealing with. However, minimizing the number of blind-zones was critical for a better result and depends on an optimum number of photos taken and used for the model. Most frequently used range was 101-150 photos with 44,6% (N:21). Range of 51-100 photos was the second with 36,1% (N: 17), and 151 and above was third with 11% (N: 8). On the lower end, only one student used a photo quantity in the range of 0-50 for the 3D modeling process.

S53 stated that they carried out the modeling phase individually, but real-

Figure 2. Model images of S56 with 570 photos (left) versus S53 with 75 photos (right).

Figure 3. Model by S59 showing the consequences of skipping the 'building dense point cloud' phase.

ized the different range of image numbers used for final models, when they came together with their peers before the presentation to compare the work they have done. However, they realized that, after a certain amount, the number of photographs did not directly affect the final product, but the photography technique used, positioning of the camera was the most important factor to get a good result (Figure 2), as well as using the needed commands.

Using the software

Between the eight fundamental steps defined in the Metashape User Manual, (2021), four of them are considered in the scope of this research. Aligning photos phase (4) produces an estimated exterior (translation and rotation) and interior camera orientation parameters together with a tie point cloud containing triangulated positions of matched image points. Building dense point cloud phase (5) includes procedures for detecting and matching points after data is loaded into the system. Building mesh phase (6) reconstructs the polygonal mesh model based on point cloud information that was generated before, and the texture feature phase (7) allows the user to build different types of textures for a model. Since the students were expected to do their own preparations using the provided and online resources, the commands they used for processing images are also examined. Answers showed that a significant number of students 78,7% (N: 37) used all the four steps mentioned above for image processing and generating the model, in Practice 1.

3D Models of students who skipped these vital steps easily revealed themselves. While models of the students who skipped phase 5 (building dense point cloud) showed blurry and watercolor like images (Figure 3), other models that skipped the phase 7 (building texture) resulted with grainy images resembling colored sand formations (Figure 4). It is understood that the model without material assignment spreads over the space as points and a clear image cannot be obtained. Students also commented that despite the existing resources and user-friendly setup of the software, "…getting good results were not that easy" (S22).

Figure 4. *Images of the model by S36 that show the consequences of skipping the 'mesh building' phase.*

4.2.4. Reflecting the lessons learnt back into action

The first practice started with a brief, addressing the resources needed for students to prepare themselves for using the introduced software. They were expected to make their own research, learn how to use the software, follow the instructions of the user manual to take the pictures, and use the commands to build up their 3D models. Evidently, student presentations and the unstructured interviews revealed success of the planned tasks. Their additional comments also made important contributions to the planning of the second study.

Technical specifications of the equipment that students were able to access and use showed that there was no need to have any concerns about the quality of the photographs or the software to work properly. However, two students who used cameras below the minimum specifications are informed about the problem, and practical solutions are discussed.

Presentations showed that not all the students did comply with the assigned learning and preparation tasks before the start. Some model images showed photography technique problems and skipped commands. Instructors gave critiques and offered solutions to correct such technical problems. Regarding the previous weeks' subjects of the course, students are reminded that the modeling software works like a laser scanner. Therefore, taking photos with a well-structured pattern, covering wider areas instead of focusing on details, using light sources effectively, and avoiding reflective surfaces are recapped once more. Regarding the photography technique, a plan diagram showing the camera movement and shooting pattern is asked to be included as a documentation, for the next practice. Also reminded that, this practice was all about BS work, and a complete set of documentation is needed to complete the asked task, not only the images of their models.

The lack of needed documentation that completes this modeling task showed the lack of comprehensive understanding of BS procedures. In order to reinforce this key, but missing viewpoint, the differences between the nature of conventional surveying methods and digital methods are given in another short presentation. The reverse order of the conventional method is highlighted as initially creating a digital model, and then extracting the needed 2D drawings with the help of technologically advanced equipment. To make students apprehend this methodological difference and understand the process in the BS context, the second practice is postponed for a week. Instead, they are asked to work on a set of predisposed orthophotos of their faculty building interior, which were created using a professional laser scanner in the previous weeks of the course to demonstrate such digital advancements in BS business.

The efforts to enable and enhance group work during the practice worked for the preparation stage of the practice. Students shared third-party resources for installing and using the software, their first experiences with the application, and some of the groups did come together and discussed the process and gave critiques about each other's 3D models. However, as the capturing and processing phases should be done separately in each student's private environment, the effort to make students work in groups delivered only a limited interaction.

4.3. Practice two

4.3.1. Action planning

In accordance with the problem definition of the study, and the outcomes of the first practice, Practice 2 started after a week's delay on the 14th week of the course schedule. Students are once more asked to use the previously introduced software, and to create a model for their household unit's kitchen area in this practice.

4.3.2. Action taking

Practice 2 is released by a similar brief, but students are asked to work on their own instead of forming groups. They are reminded of the importance of the preparation stage before capturing the photos and using the software, photography technique that will be suitable for the practice and the processing, commands that should be executed in the correct order while using the software, and most importantly, documentation of all the process as a BS work. Similar to the first task, the duration of the task is limited for a week.

While student comments and evaluations about Practice 2 are captured by unstructured interviews during and at the submission of the 3D models, following the end of the semester, a questionnaire with 19 questions is conducted. The questionnaire also tried to identify the differences between the two practices, what students made differently or used to complete the tasks. Likewise, they are asked to compare their level of satisfaction both for the process and end-products of the two practices, which also sheds light for the lessons learnt for further research studies and implementation of digital tools in BS education.

4.3.3. Observing, analyzing, and evaluating

The analysis of Practice 2 is made by the student comments during the practice and submission process, submitted 3D digital model images, and the questionnaire that is conveyed after the course period. Although the questionnaire is designed to explore the digital BS practice as a whole with both applications, the analysis and evaluations in this section are summarized using the results of this questionnaire.

Demographic data

The questionnaire received 65 replies from 67 students, and 59 of them are considered valid. Statistical validity of the questionnaire is checked for 59 replies. Sample size calculations resulted with a margin of error < 5%, with a confidence level over 95% for the population of 67 students, which is found satisfactory under these accepted metrics.

Among the 59 valid answers, 76,2% were female (N: 45) and 23,7% were male (N:14). Analysis of students' year of study showed similar distribution with the first practice. Students who were in their 3rd year of study were 55,9% (N: 33), second year were 25,4% (N: 15), and they were forming the majority. Following them, fourth years were 8,5% (N:5), and finally, fifth and six years were 5,1% (N: 3) with the same score.

Technical capabilities of the equipment used

As Practice 1 revealed, both computer and camera vise, most of the students are regarded as capable of accessing the needed equipment to use the software and fulfill the tasks. Two students who used cameras below the minimum specifications in the first practice also cleared the hurdle by employing higher resolution cameras in Practice 2.

Preparation process

Students who partially or fully read the user manual document as a preparation resource were 79,6% (N: 47). It is revealed that 20,3% (N: 12) of the students did not read the manual till the end of the second practice. Number of students who watched the videos from the provided links, for using the software were 93,2% (N: 55). On the other hand, the number of students who looked for and used an extra resource were 47,4% (N: 28).

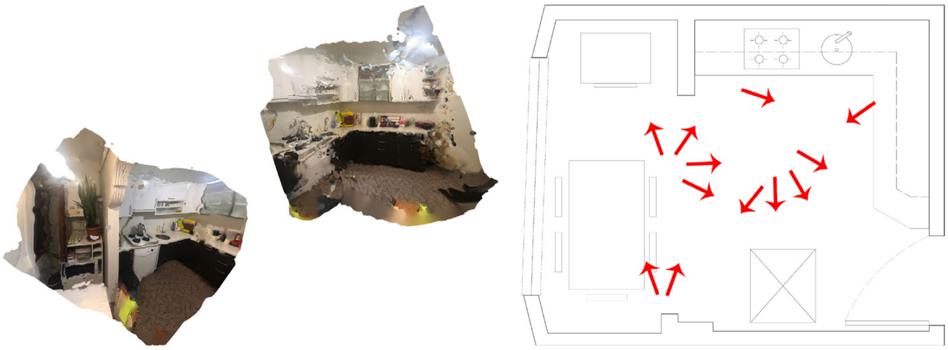

__Figure 5.__ Model created by photos taken from a couple of stationary points (S52).

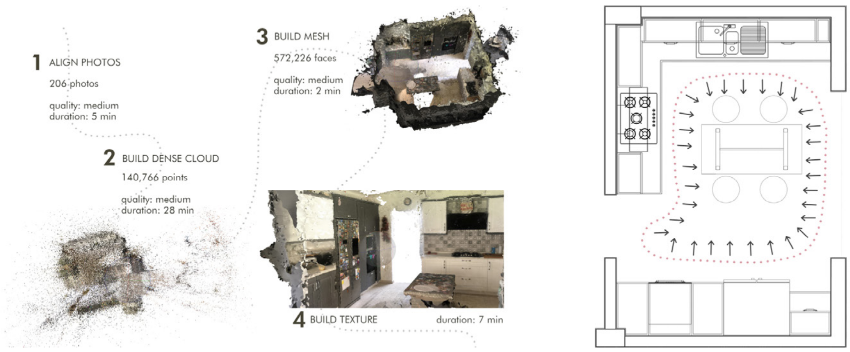

__Figure 6.__ Image capturing method and the created model in different software processes (S51).

Photography technique, source of light, and number of photos used

28,8% of the students (N: 17) used the panning method, while 42,3% of the students (N: 25) used the tracking method for capturing photographs. Only 6,8% (N: 4) of the students used both methods in combination, and a significant number of students 22% (N: 13) did not define their photography technique. In comparison with Practice 1, 6 students (10,1%) increased the number of photos they used for the final model, while 4 students (6,8%) stated that they used fewer photos. Students using photos between 0-50 were 5,1% (N: 3), between 51-100 were 28,8% (N: 17), 101-150 were 28,8% (N:17). Students who used 151 photos or more are revealed as 37,2% (N: 22) for the second practice.

Although the user manual recommended tracking method, students used different capturing scenarios. One of the frequently used photography technique by the students was taking all the necessary photos from a single or a few stationary points, by repeatedly changing the position of the camera on all three axes. However, this technique did not work well, and the photographs captured by this method caused defects on the 3D models created by the software.

While using photographs taken from a single point creates distorted model images, an increased number of stationary points may increase the quality of the end-product but still involve unpleasant distortions (Figure 5). Capturing from a stationary point changes many variables on photos, such as distance, angle, and reflection, and that causes information loss in the end-model, while photographs are being stitched together by the software. However, the sketch showing the stationary points on S52's work shows a progress towards the documentation aspect of surveying, which was missing at large in the first practice.

On the contrary, using the tracking method seems to improve the expected quality significantly (Figure 6). Learning and using the recommended technique, Student 51's (S51) work shows that keeping up with the instructions rigorously and well documenting them helps fulfilling the requirements of surveying work.

In the case of light source, 31 students used natural light, 17 students

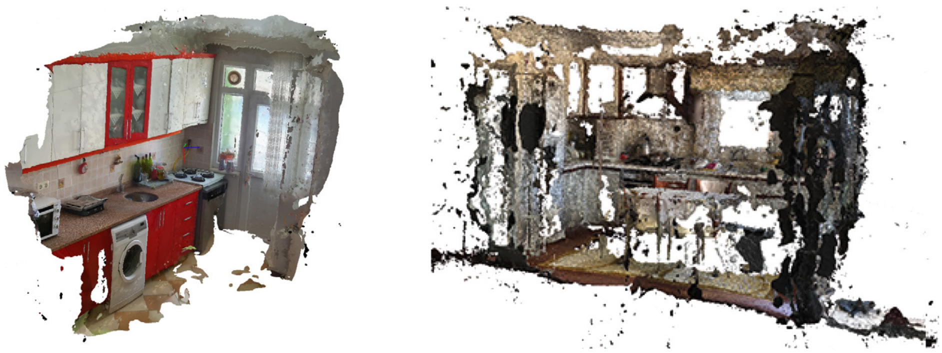

Figure 7. Two models where the natural light source ends-up with different results (left S14 and right S4).

Figure 8. Artificial light source and different effects on models (left S41, right S19).

used artificial light, and 11 students used both lights together during their photo shoot. Submissions and grades showed that the same light source did not always have the same effect on the end-model output. Figure 7 shows two different examples using natural light as their single light source capturing the photos. While S14's model achieved a better result, S4's model seems far from achieving the desired result.

Similarly, in Figure 8, two models created using only images captured under artificial light source show two different results. S41's model clearly shows the kitchen counter and cupboards clearly, while data loss is quite significant in S19's model.

Using the software

During Practice 2, 84,7% of the students (N: 50) used four key commands that were vital to get sufficient results. 11,9% (N: 7) of the students used three phases, while the remaining 3,4% (N: 2) created their model using a single command. S5 and S26, who applied only the first key command, stated that they had problems with using the software and therefore they could not apply all the necessary commands to create the 3D model. Meanwhile, there were students who skipped other phases in line, such as S59 skipping building dense point cloud phase. Results of such occasions showed data loss on the end-models despite the application of the other key phases.

4.3.4. Reflecting the lessons learnt back into action

When the submissions were examined, it was observed that the problems related to the use of the program were solved to a large extent. The interventions made in the previous practice and the students' own experiences contributed to the improvement of their work. Students tended to change the methods they used in Practice 1 to improve their studies and achieve better results. They tried to achieve good results by making changes on parameters such as light sources, number of photos, and photography technique. Consequently, it's revealed that the photography technique and use of light are as important as executing the key commands of the software to get good results. In case of light, it is understood that there are many variables that have an effect on the 3D model's quality such

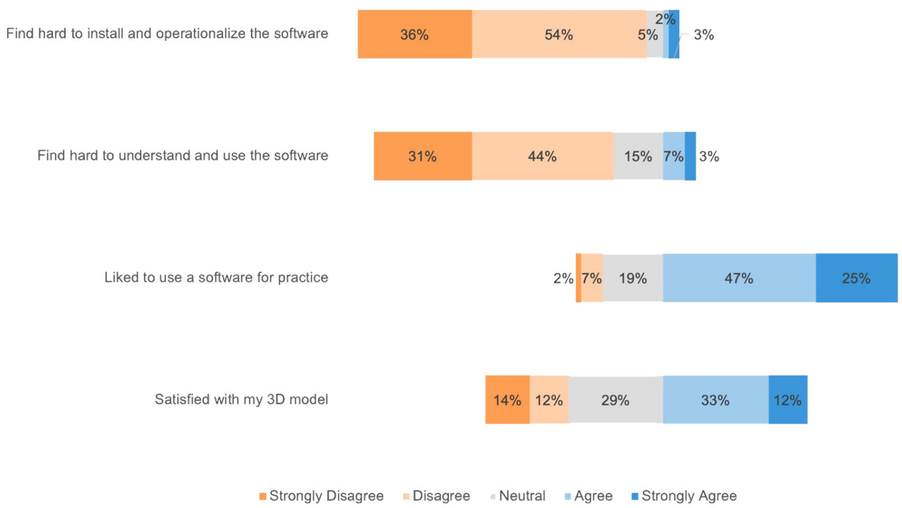

Figure 9. *Digital surveying practice satisfaction levels.*

as its direction, amount and reflections. Students learned alternatives such as using light sources together and the effect of artificial light as a fill-in light source. All in all, the results revealed that only a single parameter is not effective, and different parameters should work together to obtain a good model.

The questionnaire conducted after the semester involved four questions that were designed to collect the student evaluations for the digital surveying practice as a whole. In all four questions, their evaluations are asked using a 5-point Likert scale, starting from 1: Strongly disagree to 5: strongly agree, and 3 is used for neutral. The results are displayed in Figure 9.

The first question showed that, while 89,8% (N: 53) of the students had no problems with the digital practice, 5,1% (N: 3) had difficulties. In the second question, 74,6% (N: 44) of the students stated that they had no difficulty in understanding the software, contrary to 10,2% (N: 6). The third question revealed that 71,2% (N:42) of students liked to use it while %8,5 (N: 5) of students indicated the opposite. Finally, the fourth question revealed the approval of 45,8% of the students (N: 27), who are satisfied with their end product, contrary to 25,4% (N: 15) (Figure 9).

Another question aimed to find out students' satisfaction level from the deskwork and site work stages of the BS course. 64,4% of students (N: 38) stated that deskwork was sufficient, while 6,8% (N:4) of students disagreed, and 16,9% (N:10) stayed neutral. 27,1% of the students (N: 16) specified that site work was sufficient, contrary to 35,6% (N: 21). 25,4% (N:15) stayed neutral. Both deskwork and sitework questions are not answered by 11,9% (N: 7). Meanwhile, the statistical analysis to explore possible relationships between students' gender, year of study, preparation and methodological behaviors, and evaluations did not show any statistically significant relationships.

Despite some improvement, most of the students did not properly document the process as needed, although its importance has been prompted on the brief and reminded throughout the course.

5. Discussion and recommendations

The work expected from the students through a surveying software took place within the scope of the building surveying education. Practice 1 started with capturing photographs and creating 3D models of student rooms, using the designated software. Photography technique, number of photos used, and light source, camera and computer system specifications are examined while students represent their models as a group. During the presentations, instructors gave critiques about their survey work and prepared students for the next step of the research. For Practice 2, students are asked to work on their kitchen space by considering the lessons learned from Practice 1.

All the students managed to install and run the software and the number of students who read the tutorial and checked other resources were significantly high. Correspondingly, the analysis of student evaluations shows results more on the positive side, with comments like "…(was) fun and efficient…" (S17) or "… (the instructors) did everything to adapt the online education process…" (S10).

However, there were also critical comments given to the open-ended question. Main topics of criticism were about the difficulty of using the software, problems about the surveyed space, and problems arising from misunderstood contextual associations. While some students complained about the software as "technically very incomplete" and having a "complicated interface" (S57) or gave statements such as "I could not get enough efficiency from … the software" (S07), their subsequent comments as well as other student critics pointed out the real problem that arises from difficulties, they encountered during capturing their photos. S57 stated "…with dense interior spaces, the software remains very weak, it could not model most kitchen items" indicating problems arising from the space itself, with similar comments such as "…it was hard to produce data from a narrow area…" (S07), "my final model was not satisfactory, probably because of the narrow space" (S35).

The feedback provided by the students and the observations showed that the kitchen space was appropriate to the aim of making students perceive the capabilities of a digital photogrammetry practice. As a common space that every student can reach in their own habitat, the kitchen was compact yet full of details and tricks. In particular, the excess of reflective surfaces, mechanical and electrical appliances, combinations of portable and fixed furniture, with a limited movement area, gave useful hints about the conventional practice of surveying and helped students generate ideas about how fieldwork and digital tools could come together.

Other student comments added up on the challenges they faced with their photography technique. One student commented on how they solved problems in their model by experimenting with natural and artificial light: "…with natural light in the second practice, … homogeneously dispersed and no burst of light, I got more efficient results" (S03). Although the success of photography technique depends on a couple of variations, and there is no single recipe that is clearly given for the use of light sources in the user manual, this comment shows that students can take initiative to solve problems they face and try to improve their work, when they have to.

Unfortunately, one of the comments showed the gap between the practice and the surveying context, showing the software may be considered as a modeling program only: "…It would be easier if I modeled by myself using Sketchup or 3ds Max instead…" (S57). Despite the contextual framework of the BS course and recurring reminders, this comment prompts the need for going further with the digital practice and extracting orthophoto drawings from the 3D model to complete the learning cycle.

Capturing and presenting personal spaces is also a delicate subject where privacy should be given top priority. Although students who mentioned their concerns are given the flexibility to choose other spaces that will not bother them at the briefing stage, one of the comments showed that some students may be staying silent during the process but admitting it later: "Unfortunately, doing such practices in my room annoyed me, because I did not want my room to be seen by others" (S23). Whether they are cultural or economical, such distress should be handled with care by the educators at every stage of the curriculum.

Taking AR methodology as a reference point, the digital surveying practice discussed in this study forms two recurring cycles that tackle the problem of implementing digital surveying tools into the curriculum. While two sets of practices are used in this case, it is obvious that increasing these cycles of research units would help to improve the results. However, the lockdown conditions restricted the development of a more robust and extensive research experiment and limited the time spared for this set of practice. In this respect, these recommendations are compiled for future researchers:

- Students of design-based degree programs such as interior architecture have computers with technical specifications that are capable of handling diverse software that can be used as a learning interface. Smartphones have become ubiquitous tools that almost every student has. These devices are capable of doing more than we are currently using them for and their camera capabilities are in corroboration with the research of Caroti & Piemonte (2020). Educators should be more willing to integrate digital practices into their curriculum, regarding the current state of technology that students are using in their daily life.
- The nature of the online education environment requires problem solving and new skills learning via the internet. Results of this study shows that students are willing to experiment with new digital tools. Online tutorial-based learning success seems natural for a significant amount of students just like Fleischmann (2020) points out. However, the remaining students have to be supported with external resources, such as video tutorials.
- The group work requisite of conventional surveying methodology is one of the vulnerable points in digital surveying practice. The need to cooperate while doing the surveying work, brings student-student interaction both helps improve the quality of survey documents, and adds up to education. However, the desired instructor-student interaction for digital practice still requests a closer ratio such as 1:2 or 1:3 just as Mika (1999) points out for the conventional surveying education.
- Digital production tasks should be designed to incorporate more with the necessities of the surveying practice, giving due importance to the documentation stage.
- The subject matter of the practices should be selected in compliance with potential sensitivities of students. As some students may find sharing images of their habitat intimidating, these students should be given more flexibility to convince them to participate in such practices. As the main goal is the practice of digital tools, such problems can be eliminated by providing alternative themes.
- Instructors should keep the course on track considering the objectives of the course, avoiding unnecessary focus on the software or digital tools being used for surveying practices.

6. Conclusion

This action research case comprised two surveying practices that tried to compensate for the site work of the BS course that could not be done by the conventional methods due to the pandemic measures and lockdowns. As the classes were being done online in digital mediums, students are encouraged to use digital equipment and software to capture and produce 3D models of their subject space in their own living environment. Although the digital measuring and modeling process changed the order of conventional surveying by creating the model before the 2D documents, the research aimed at introducing digital technologies that are strengthening their presence in the architecture and engineering industry with an increasing pace.

The results showed the eagerness of the students to use digital tools, their ability to learn new skills through the internet and to use the necessary software to practice BS while experiencing an unexpected online education semester. The progress between the stages of AR cycles proves the students' ability of learning-by-doing and learning from their mistakes. Results also show some shortcomings of the research, such as failure to compensate the group work, falling short to integrate the documentation stage into the practice, and its limited application area in a single surveying class.

BS happens to be one of the first professional real-life experiences for new graduates, especially those who will be employed in firms dealing with adaptive reuse projects. Interior architects deal with existing structures and spaces most of the time, and relatively, they deal more with details. Therefore, the curriculum should pay attention to building surveying it deserves, keeping in mind that BS is not an expertise area that belongs to historic preservation only, but it is also a part of contemporary architecture.

BS techniques are changing with the impact of IT developments, and these improvements should also be integrated into the curriculum. The online emergency education period due to the pandemic showed that integrating digital practices into the curriculum may not be that far away. Aiming for the future, new educational tools and material should be developed for using the advances of IT, considering the aims and objectives of the BS courses.

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