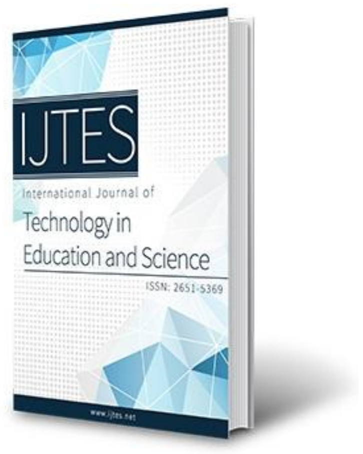

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Investigating the Impact of Simulation Software on Students' Learning Processes

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Abstract

Due to the frequent utilization of technological applications in contemporary times, the quality of educational processes is rapidly evolving. This study examines students' experiences through simulation software applications. A mixed-method design is employed due to the combined use of qualitative and quantitative data collection methods. Accordingly, Achievement tests, Semi-Structured Interview Form, Observation Form, and Simulation Software Participant Applications Evaluation Form were utilized for data collection. All obtained data were analyzed to support and compare the findings of the study. As a result of the study, some positive effects of simulation software on students' learning processes are identified. Among these outputs, it is highlighted that throughout the process, students' levels of achievement increase, and due to the smooth operation of the applications, students experience a sense of achievement and positive attitudes. It has been observed that as students' experience with the simulation software they use increases, they are able to perform subsequent applications almost flawlessly. Finally, it has been noted that some students resist these processes and their development is limited. Among the recommendations of the study, it is suggested that structured learning activities through such simulation software would be beneficial.

Introduction

It is widely accepted that one of the most significant indicators of competitiveness in universities is the use of new technologies in the teaching-learning process. In this context, the effective and efficient use of new technologies plays a crucial role in enhancing universities' success and visibility. Indeed, various studies confirm that simulation applications contribute significantly to improving students' practical skills and competencies. In particular, simulation technologies stand out as an effective tool for developing students' theoretical knowledge and practical skills (Chernikova, 2024; Koolivand et al. , 2024).

Simulation software has emerged as a transformative tool in education, offering dynamic and interactive learning experiences that enhance student engagement and understanding. These programs create virtual environments where students can experiment and explore complex concepts in a controlled setting, thus facilitating experiential learning (de Jong & Joolingen, 1998). The application of simulation software spans various disciplines, including medicine, engineering, and natural sciences, providing realistic scenarios that are often impossible to replicate in traditional classroom settings (Gredler, 2004). Research indicates that simulation-based learning can significantly improve knowledge retention and skill acquisition (Cook et al. , 2013). Therefore, integrating simulation software into educational practices is crucial for fostering deeper learning and preparing students for real-world challenges (Alessi & Trollip, 2001).

Building on the advantages of simulation software, learning activities that incorporate these tools are designed to be interactive and student-centered, promoting active learning and critical thinking (Garris, Ahlers, & Driskell, 2002). These activities often involve problem-solving tasks, exploratory learning, and decision-making scenarios that require students to apply theoretical knowledge in practical contexts (Cheng et al. , 2014). The use of simulation in learning activities has been shown to enhance student motivation and engagement by making learning more relevant and enjoyable (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Furthermore, simulation-based learning activities provide immediate feedback, allowing students to learn from their mistakes and improve their performance (Rosen et al. , 2010). As educational paradigms shift towards more interactive and personalized learning experiences, the role of simulation software in facilitating effective learning activities becomes increasingly significant (Kolb & Kolb, 2005).

The impact of these advanced learning activities on student success is noteworthy. Student success is a multifaceted construct that encompasses academic achievement, skill development, and overall satisfaction with the learning experience (York, Gibson, & Rankin, 2015). Simulation applications are regarded as an effective teaching strategy that contributes to the training of skilled and competent professionals by allowing students to repeatedly practice both technical and non-technical skills until they gain confidence (Fegran et al. , 2023; Kim & Kim, 2017). Moreover, simulation applications support the learning process by enhancing students' critical thinking skills and self-efficacy, which is why they are frequently used in both undergraduate and graduate-level education (Hall & Tori, 2017; Fey, 2014; Levett-Jones & Lapkin, 2014). In addition, research has shown that students not only develop teamwork and communication skills but also improve their collaborative competencies (Sezgin & Bektaş, 2023). The integration of simulation software in educational settings has been linked to improved student outcomes across these dimensions (Lateef, 2010). By providing hands-on experiences and practical applications of knowledge, simulation software helps students to better understand and retain complex concepts, thereby enhancing academic performance (Brinson, 2015). Additionally, the interactive nature of simulation-based learning can foster important skills such as critical thinking, problem-solving, and collaboration (Schmidt et al. , 2015). Consequently, the use of simulation software not only supports academic success but also prepares students for professional success in their respective fields (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005).

In exploring the role of educational technologies, including simulation software, it becomes evident that they are pivotal in modernizing education and aligning it with the needs of the 21st-century learner (Johnson et al. , 2016). These technologies facilitate access to a wealth of information and resources, enabling personalized and self-directed learning (Means, Toyama, Murphy, Bakia, & Jones, 2010). The adoption of educational technologies has been shown to enhance the quality of instruction and make learning more accessible and inclusive (Selwyn, 2012). Simulation software, as a component of educational technology, contributes to this by providing innovative ways to engage students and enhance their learning experiences (Huang, Rauch, & Liaw, 2010). As educators continue to integrate technology into their teaching practices, understanding the impact of these tools on learning outcomes becomes essential (Kirkwood & Price, 2014).

In conclusion, the integration of simulation software into educational practices represents a significant advancement in teaching and learning. By providing interactive and experiential learning opportunities, simulation software enhances student engagement, facilitates active learning, and improves academic outcomes. The use of simulation in learning activities promotes critical thinking and practical skill development, which are essential for student success. As educational technologies continue to evolve, incorporating simulation software into curricula will be vital for preparing students for the demands of the modern world. Future research should focus on optimizing the use of simulation software and exploring its long-term impacts on educational outcomes.

Literature Review

Simulation software has gained significant traction in educational settings due to its ability to create immersive and interactive learning environments. These tools allow students to engage with complex scenarios and practice skills in a risk-free environment, which enhances their learning experiences (Gredler, 2004; de Jong & van Joolingen, 1998). The use of simulation software spans various disciplines, including medicine, engineering, and natural sciences, making it a versatile tool in modern education (Alessi & Trollip, 2001). By simulating real-world situations, these tools provide students with hands-on learning opportunities that are often difficult to achieve through traditional teaching methods (Cook et al. , 2013).

The integration of simulation software into educational practices has shown to be particularly beneficial in enhancing student engagement and motivation. Research indicates that students who use simulation tools are more likely to participate actively in their learning processes, leading to better retention and understanding of the material (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013; Garris, Ahlers, & Driskell, 2002). This increased engagement can be attributed to the interactive nature of simulations, which require students to make decisions, solve problems, and think critically (Cheng et al. , 2014). Furthermore, the use of simulation software provides immediate feedback, allowing students to learn from their mistakes and improve their performance (Rosen, 2010).

The effectiveness of simulation software in improving student learning outcomes has been well-documented. Studies have shown that students who engage with simulation-based learning achieve higher academic performance compared to those who rely solely on traditional instructional methods (Brinson, 2015; Issenberg et al. , 2005). This improvement is often attributed to the experiential learning opportunities provided by simulations, which help students to apply theoretical knowledge in practical contexts (Kolb & Kolb, 2005). Additionally, simulation-based learning has been found to enhance critical thinking and problem-solving skills, which are essential for success in various professional fields (Schmidt, Rotgans, & Yew, 2011).

While the advantages of simulation software are numerous, it is important to acknowledge the challenges and limitations associated with its use. One major concern is the significant investment required for developing and maintaining high-quality simulation tools (Johnson et al. , 2016; Lateef, 2010). Educational institutions often face financial constraints that can limit the widespread adoption of simulation software. Moreover, there is a need for adequate training and support for instructors to effectively integrate these tools into their teaching practices (Tondeur et al. , 2017; Koehler & Mishra, 2009). Without proper training, the potential benefits of simulation software may not be fully realized. Another significant advantage of simulation technologies is their potential to overcome environmental constraints, offer frequent training opportunities, provide instant feedback, and enable real experiences in a simulated environment. These advantages have led to the rapid expansion of simulation applications in the field of education (Im, Gu, Lim & Lee, 2023; Liebermann & Erdelt, 2020). Furthermore, simulation technologies are known to improve learning environments by reducing students' ongoing anxiety throughout the educational process (Jung et al. , 2012). Although some negative effects of simulation applications have been found in areas such as anxiety, cognition, creativity, gender differences, learning attitudes, and student satisfaction, overall, they have been shown to exert a strong and positive impact on educational outcomes (Zhonggen, 2023).

Another potential drawback of simulation-based learning is the risk of over-reliance on technology. While simulations can provide valuable learning experiences, they should not replace traditional teaching methods entirely (Selwyn, 2012). A balanced approach that combines simulation-based learning with other instructional strategies is necessary to ensure comprehensive education (Means, Toyama, Murphy, Bakia, & Jones, 2010). Furthermore, there is a need for ongoing research to evaluate the long-term impact of simulation software on student learning outcomes and to identify best practices for its use (Huang, Rauch, & Liaw, 2010).

Despite these challenges, the future of simulation software in education appears promising. Advances in technology continue to enhance the capabilities of simulation tools, making them more realistic and accessible (Kirkwood & Price, 2014). The use of virtual reality (VR) and augmented reality (AR) in simulations is an emerging trend that offers new possibilities for immersive learning experiences (Johnson et al. , 2016). These technologies can further enhance student engagement and provide more realistic practice environments (Cook et al. , 2013).

In conclusion, simulation software represents a powerful tool for modern education, offering numerous benefits for student engagement and learning outcomes. However, the successful integration of these tools requires careful consideration of the associated challenges and limitations. By addressing these issues and adopting a balanced approach to instructional strategies, educators can leverage the strengths of simulation software to create more effective and engaging learning experiences. Future research should continue to explore the potential of emerging technologies in simulations and identify best practices for their implementation in educational settings.

Simulation software has emerged as a critical tool in the field of educational sciences, facilitating the practical application of theoretical knowledge. These software tools recreate complex and real-world scenarios in a controlled and safe environment, significantly enhancing student engagement in active learning processes (Gredler, 2004; de Jong & van Joolingen, 1998). The use of simulations in education offers experiential learning opportunities, making learning outcomes more durable (Kolb & Kolb, 2005). Additionally, simulations allow students to experience scenarios they might rarely encounter, enriching their learning experiences (Cook et al. , 2013).

The application of simulation software is particularly prevalent in disciplines such as medicine, engineering, and the sciences. These tools help develop critical thinking and problem-solving skills, while also increasing student interest in their subjects (Cheng et al. , 2014; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Research indicates that students who engage in simulation-based learning tend to achieve higher academic performance compared to those using traditional learning methods (Brinson, 2015; Issenberg et al. , 2005). Simulations enable students to integrate theoretical knowledge with practical application, thereby enhancing their understanding and ability to apply knowledge in real-world settings (Schmidt, Rotgans, & Yew, 2011).

However, integrating simulation software into education presents several challenges. Developing and maintaining these tools require substantial financial investment (Johnson et al. , 2016; Lateef, 2010). Educators also need adequate training and support to use these technologies effectively (Tondeur et al. , 2017; Koehler & Mishra, 2009). Over-reliance on technology poses a risk as well; simulations should not entirely replace traditional teaching methods (Selwyn, 2012). Therefore, simulation-based learning strategies should be balanced with other instructional methods (Means, Toyama, Murphy, Bakia, & Jones, 2010). By doing so, the potential benefits of simulation software can be maximized, creating a more effective and engaging learning environment.

Nowadays, technological devices that we frequently use also affect the education system. This technological impact improves the quality of educational processes. Through these developments, richer learning environments can be created for learners. Simulation software is among these technological developments. In professional practices conducted with simulation software, learners can perform applications similar to real-life applications. Consequently, learners can gain more experience, and the costs and potential negative situations of real applications can be minimized. This study examines the effects of using simulation software on students' professional development. Research questions of the study in line with this purpose:

1. What is the impact of simulations on student achievement?
2. What are the students' level of using simulation software?
3. What are the professional impacts of simulation software?
4. What are the interactions among students while using simulation software?
5. What are the reactions of students as a result of running the simulation software?

Method

The study was conducted using a mixed-methods design. Both quantitative and qualitative data were collected in the study. In a robust mixed-methods study, it is important for qualitative and quantitative data to be complementary (Tashakkori & Creswell, 2007). Dabbs (1982) stated that the quantitative approach is necessary for the amount of certain things, and the qualitative approach is necessary for the nature of things. In the first phase of the study, data were collected using quantitative techniques. Within this scope, the professional skill development of participants using simulation software was monitored. In this study, which employed the descriptive survey model from quantitative research methods, data were collected to reveal the characteristics of a determined group. In the survey model, the research subject is described as it is and is not altered or affected by anything (Karasar, 1998). Qualitative methods were continued in the study to explain, support, and compare the quantitative data. Qualitative research allows for the examination of an existing phenomenon from the participants' perspectives (Merriam, 2009). In the study, a case study design was used, which allows for an in-depth examination of a limited situation (Yıldırım & Şimşek, 2008). Data were collected through semi-structured interviews, observations, and software evaluation forms. Face-to-face interviews were conducted with six participants. The interview method is expressed as an effort to understand and comprehend events from the individuals' perspectives (Patton, 1987).

Participants

All participants in the study were students studying at a state university in Istanbul. Before data collection, ethical approval was obtained from Istanbul University-Cerrahpaşa, Social and Human Sciences Research Ethics Committee. The principle of voluntariness was considered in all data collection processes where participants expressed their views. Detailed information was provided to participants at all stages. Data were only collected from participants who gave their consent throughout the study. Potential participants were reached through detailed announcements made in the classroom before the study began. It was stated in these announcements that no data that directly or indirectly pointed to the participants or the institution they studied at would be used at any stage of the study. After ensuring that the participants wanted to participate in the study, an informed consent form was read and signed. Of these participants, 16 (47. 06%) were vocational high school graduates, and 18 (52. 94%) were general high school graduates.

Participants who expressed their views in the achievement tests were followed for two semesters. At this stage, the effects of simulation software on participants' development were examined. Thirty-four participants took part in the achievement test phase of the study. The face-to-face interview dimension of the study included six students. Criterion sampling was used to include participants in the study. These participants were selected from students who took elective computer programming courses for two semesters. It was planned to conduct the study with three participants showing the most positive development and three showing the least development based on the achievement tests.

Data Collection

Four data collection tools were used to increase the diversity of data in the study, ensure a comprehensive understanding of the study, and obtain comprehensive findings. These tools are (1) Achievement Tests, (2) Semi-Structured Interview Form, (3) Observation Form, and (4) Simulation Software Participant Application Evaluation (SYKUD) Form. Two educators who are experts in technology use assisted in developing the data collection tools. The experts checked the data collection tools and ensured they were appropriate for the participants' level. Ethical approval and necessary permissions were obtained from Istanbul University-

Cerrahpaşa, Academic Ethics Committee, before data collection. After obtaining the necessary permissions from the committee, data collection processes began.

Achievement Tests

Achievement tests were developed to monitor the changes in participants' success over two semesters. During the development processes of the tests, participants' professional software use skill levels were considered. In this context, the achievement tests for each semester were prepared in two equivalent forms. The stages of preparation, checking and suitability of achievement tests for the study were supervised by two experts. After the forms applied in the Spring Semester of 2019-2020, the achievement tests for the Fall Semester of 2020-2021 were prepared considering the students' skills. All tests were structured to reflect the participants' professional skills in the applications. Equivalent forms of the tests for the relevant semester were applied eight weeks later.

Semi-Structured Interview Form

One of the main data collection tools of the study is the semi-structured interview form. This form examined the dimensions of simulation software use, professional development, and participants' problem-solving skills. Face-to-face interviews were conducted with six participants using the form. Semi-structured interview forms allow for systematically and consistently asking predetermined questions to the interviewee and provide the opportunity to go beyond the standard responses to these questions (Berg, 2012). Before the data collection processes, detailed information about the study was provided to potential participants. These briefings clearly expressed the study's method and processes. Before conducting the interviews, all participants were asked for a suitable time. Interviews were conducted on the day and time indicated by the participants. Before starting the interview, the informed consent form was read and signed by all participants. Permission was obtained from the participants before recording the interviews. All interviews were recorded with a voice recorder.

Observation Form

Efforts were made to include the behaviors demonstrated by students while performing simulation applications in the study. At this stage, the use of a video recording device was preferred. However, since some students did not accept having their photos taken at certain intervals, no video or image recording was made. Instead, data were collected through observation. Before the observation in the classroom environment, students were briefed about the study and the observation to be conducted. In this briefing, the study's scope and the planned observation method were clearly stated. It was expressed that participation in the study was based on the principle of voluntariness. It was also stated that no sanctions would be applied to students who did not want to participate in the study. It was expressed that it would be sufficient for students who did not want to participate in the study to inform the researcher at the specified e-mail address. During the observation, participants were observed completing their software applications in the computer laboratory and running them on the simulation. Within this scope, (1) carefulness in performing applications, (2) answering other classmates' questions, (3) problem-solving, and (4) conducting applications outside the class hours were observed. The observer positioned themselves in an angle where they could see the students face-to-face without hindering the applications. Participants were followed for two class hours, and relevant notes were taken. Before the second lesson began, the observer positioned themselves in the diagonal of the place they sat during the first lesson. This provided a broader observation area. No personal data related to any participant was recorded during the observation.

SYKUD Form

To enhance the diversity of qualitative data in this study, an analysis of the participants' simulation applications was also conducted. Five of the participants included in the interview voluntarily provided access to all their applications. Figure 1 shows screenshots of two of these applications. This allowed the researcher to access the applications with the participants' sharing permission. In the examination, 34 applications were reviewed for five participants. The applications were evaluated based on (1) graphical connections, (2) coding, (3) difficulty, (4) running, and (5) professional dimensions. For each dimension, four criteria were examined: dimension not provided, dimension incompletely provided, dimension provided and advanced level.

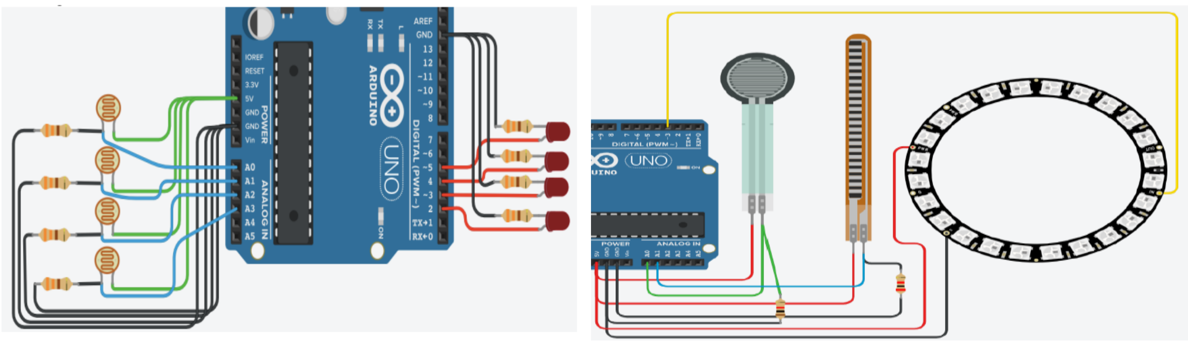

Figure 1. Screenshots for Two Simulation Applications

Before selecting the simulation software for the study, various examinations were conducted regarding simulation software. In these examinations, it was observed that these software programs are generally grouped into four categories: (1) allowing visual schema design, (2) allowing both design and simulation, (3) web-based, and (4) paid/free. Some of the software in these groups were found to have multiple options. The simulation software used in the study was selected to be free, web-based, allowing visual design, and simulation, and appropriate for the students' level. This allowed students to continue their work from any computer with internet access. Additionally, all applications requested from participants throughout the semester were directly professional. This aimed to ensure that participants' interest in the applications was sufficient.

Triangulation was performed to ensure the diversity of qualitative data in the study. Triangulation is defined as the use of multiple forms of qualitative research methods (Denzin, 1970). In this respect, triangulation can be expressed as an attempt to provide an in-depth understanding of the phenomenon (Denzin, 2012). The use of interviews, observations, and the SYKUD form in this study aimed to ensure triangulation. In studies where data diversity is ensured through triangulation, the risk of limitation and bias is minimized, and validity is maximized (Maxwell, 1996).

Data Analysis

The scores from the achievement tests, which are part of the quantitative data, were subjected to dependent groups t-test analysis in SPSS software. The voice recordings obtained from face-to-face interviews were transcribed and transferred to a digital environment. To prevent data loss, transcribed texts and voice recordings were synchronously checked. These data were emailed to the participants in the study. In this email, participants were asked to check the text and convey any statements they did not want to be included in the study. During this stage, no participant requested any change. Subsequently, coding was performed for the qualitative data. In the data analysis stage, the data obtained from the interviews were first divided into general topics, coded, and subthemes were created under the themes. Initially, a general framework was created to present the participants' views on the research problem as subthemes under general themes. Descriptive analysis was performed on the qualitative data in the study. Descriptive analysis allows the collected data to be presented in an organized and interpreted form (Yıldırım & Şimşek, 2008). In the descriptive analysis, first, general themes were formed, followed by subthemes based on the research questions. Codes were created under these themes. To increase the validity and reliability of the qualitative data, expert opinions were consulted (Merriam, 2009). In the qualitative data analysis, two educational science experts were consulted for the general framework of the data. The qualitative data was coded by two different experts. To increase reliability, Cohen's kappa analysis was performed on the qualitative data coded by the experts. The agreement coefficient (Cohen's kappa) calculated based on this analysis was found to be 0. 89. A kappa value of 0. 89 indicates a high level of agreement (Landis & Koch, 1977). The process of consulting expert opinions is considered important in data analysis and increases reliability (Yıldırım & Şimşek, 2008).

In the quantitative data analysis, dependent groups t-test was conducted in SPSS software. In the qualitative data analysis, descriptive analysis was performed on the data obtained from semi-structured interviews, observations, and SYKUD form evaluation. The diversity of data sources and the complementarity of quantitative and qualitative data were ensured to obtain robust findings in the study. The importance of including both quantitative and qualitative data in mixed-methods studies is highlighted (Creswell & Clark, 2017). In this context, efforts were made to achieve data triangulation in the study. For all analysis stages of the study, expert opinions were consulted. The consultation of expert opinions is emphasized as important in achieving robust findings in the study (Patton, 2014).

Ethical Considerations

Ethical approval was obtained for the study from Istanbul University-Cerrahpaşa, Academic Ethics Committee. The principle of voluntariness was upheld in all data collection processes. Participants were informed about the study, and their consent was obtained before collecting data. Participation in the study was based on the principle of voluntariness. Participants were assured that no data that directly or indirectly points to them or their institution would be used at any stage of the study. Participants were provided with detailed information at all stages of the study. Data were collected only from participants who gave their consent. Data collection was only performed with participants who gave consent

Results

The effect of university students' use of simulation software on their professional development and achievement levels has been examined. In this section, the data obtained through the four data collection tools used in the study have been analyzed. The analyses aimed to gain an in-depth understanding of the data. The findings related to the first data collection tool, the Achievement Test, are presented in Table 1.

Table 1: Achievement Test Results of Participants

		$\bar{x}$	n	ss	t	df	p
2021-2022 Spring	Pre-test	43.26	34	17.96	-7.665	33	.000
	Post-test	64.38	34	20.41			
2022-2023 Fall	Pre-test	47.41	34	21.93	-8.270	33	.000
	Post-test	60.32	34	19.49			

According to the findings in Table 1, it was determined that the use of simulation software by the participants resulted in a significant difference in their achievement in both periods. This indicates that there is an effect on the participants' professional development.

In the second phase of the study, the themes, categories, and codes emerging from the analysis of data obtained through interviews, observations, and the SYKUD form are presented in this section.

Theme 1: Simulation Software

When the data obtained in the study were analyzed, it was found that numerous experiences related to simulation software stood out among the participants. Within these experiences, it was understood that the use of simulation software could prevent damage caused by incorrect or incomplete connections of circuit components and ensure the implementation of safety measures. It was stated that potential errors could be foreseen in advance, leading to the careful use of expensive equipment. This kind of use provided financial advantages for the participants. Instead of performing each application individually with students in crowded classes, it was indicated that example applications were presented with video support, and students carried out practices that enhanced their individual experiences. Before performing physical applications, circuit designs could be seen, and the roles of circuit components were better understood by the participants. All these data indicate that simulation software has significant advantages and that these advantages are utilized by the participants. Some direct quotations from the participants and a portion of the data from the SYKUD Form are provided below.

> *Umut: "Like Kerem, for example, when I get on a metro, a light shows which station we are at. I had thought a lot about how this was done. After all, the train moves on a track. And they see this at hundreds of places in the control room. I thought to myself, this can be done this way, but it can also be done that way. We learned it in the software, and we see the sensors and everything."*
> *Batuhan: "Well, since I already have a set, I don't prefer to use Tinkercad much in my daily life, but it is*

very beneficial for learning because, as I mentioned earlier, it is easy to access from another place instantly, and it keeps your set safe, plus it saves time. Especially now, in these years, saving both time and money is very important. If it saves you time and money and teaches you very well, the program is very useful. In my opinion, it is beneficial. "

Selman: "For instance, a mistake in the software can ruin the setting of a sensor. If we send energy from the wrong place, that leg might get damaged. Testing the project through simulation allows us to foresee such errors in advance. In this regard, Tinkercad is very advantageous."

SYKUD Form: "In some applications, carelessness was observed in forming schematic connections. However, the fact that all applications worked can be interpreted as students fulfilling their tasks. Almost all applications worked without any problems. The applications that did not work were due to unnoticed definition deficiencies. "

The use of simulation software has been found to prevent damage resulting from incorrect circuit connections. Consequently, safety is enhanced, and financial savings are achieved. Additionally, video-supported example applications encourage students to gain individual experience, facilitating a better understanding of circuit components and their functions.

Theme 2: Professional Effect

Professional qualifications are among the most important factors in participants' ability to practice their profession after graduation. In this context, it is vital to follow the professional development of the participants throughout their education and to choose practices appropriate to their professional development. When the interviews with the participants and other data collection tools were examined, important findings were obtained regarding the professional development of the participants. One of the most important outcomes in increasing the professional development and experience of the participants was revealed by the participants expressing that they were able to transfer what they learned to other courses. At the same time, it has been stated that with increasing experience, professional situations in daily life are first noticed and then this leads to research on how these systems work. It has been stated that over time, it has been realized that professional practices take place at every stage of life. This also made positive contributions to the individual development of the participants. It has been stated that over time, changes in application and simulation methods in courses are perceived as supporting innovations. It was stated that the participants' sense of responsibility towards business life was strengthened by increasing participant experiences, supporting professional development, and seeing the implications of the practices in daily life. It has been stated that better results can be achieved if the applications are suitable for the level of the participant, and in this case, it will have a positive contribution to the development of the students. It is understood that they are getting better over time and adapting to new applications faster, thanks to their increased experience. It was observed that they benefited from their instructors, peers and the internet environment while solving the problems they experienced. Some of the participant opinions regarding the theme are given below as direct quotes and some of the Observation Form data.

Observation Form: Some participants research the elements they will use in the circuit in more detail on *the internet before performing the simulation. When asked the reason, the answers were "Making sure that the circuit elements are connected correctly for the simulation and understanding the working structure of these circuit elements. "*

Ahmet: It was of great help to me. For example, while I was solving something in mathematics, or there was a prime number issue recently, after learning how to code, such as how can I solve this with code, or how I can do it if I make a software or Android software and put it on my phone, I started to think about how I can do this with coding or a small intervention in many of the tasks I encounter in my life. So it happened.

Kerem: …when I get on the bus, when I press the button, the sign that will stop is on. When I was a kid, I used to think about how they do these things. In Anatolian high school, I took courses such as mathematics, physics and chemistry. Now when I see these, in coding, the signal goes from here and gathers here. ... "This is how the coding of what I see is done, I would do it like this. " When I look at a machine, rather than nothing, we say there is a conveyor belt here, there is a weight sensor there, it will stop according to the weight sensor, and it broadens our perspective.

Umut: We learn the logic of the business in a professional sense, and when we go to the market, what is and how is formed in our minds. My professional foundation was laid here. But I do not use this (Arduino) professionally.

Batuhan: The level of applications is quite good, there are those who have a basis and there are those who do not, so it makes sense to start from the simplest and move on to applications where more complex components increase, so the level we are at in applications right now seems sufficient and good to me.

One of the most crucial factors supporting participants' professional development is their ability to transfer acquired knowledge to different courses and recognize professional situations in daily life. Innovations in simulation and application methods have been found to promote development, while increasing experience strengthens participants' sense of professional responsibility. Furthermore, when applications are tailored to appropriate levels, participants demonstrate faster progress and adapt more easily to new situations.

Theme 3: Transferring Experiences to Peers

When the data sources obtained within the scope of the study are examined, it is understood that the participants helped each other at a significant level. Although it was stated that the simulation applications were suitable for the student level, it was stated that the participants should be in a continuous development cycle. For this reason, it was stated that the participants also have certain duties in terms of their professional and individual development and that they must fulfill these duties. It has also been observed that they consulted their friends right next to them when they had problems and their problems were solved. In this way, it is understood that peers continue their journey among themselves faster and with solutions appropriate to their level. It was stated that participants who asked questions often received help easily from other peers. In this context, it has been observed that peers help each other in problem solving. It appears that participants learned better after each problem solution, including situations where they solved their own problems. Because it has been observed that subsequent applications are made faster and with fewer problems. Some of the participant opinions regarding the theme are given below as direct quotes and some of the Observation Form data.

> *Observation Form: Some students finished their practices earlier than other students. These students also help other students who could not complete their applications or are having problems. In this way, all students completed their applications. The first students who successfully completed their applications also explain the working principles of the simulation and where they have deficiencies.*
>
> *Umut: Frankly, I also encounter problems during simulation. In codes run by both myself and my friends. What I do is research on the internet. I'm not doing anything very different. Frankly, people are lazy about this. I can learn more by dealing with other people's problems.*
>
> *Kerem: ...yes, you are doing the applications here in the fastest way, but we need to ensure professional competence and research. If we cannot research ourselves, the information here will remain here. The more we improve ourselves, we have three courses directly related to programming. I set it up and look at how we develop it. Since the project we did for the course, factory automation with its content, attracts my attention more, I am learning and developing how to solve those complex systems. There is control and automation in the things we do. There is still automation in what we do, but we are more minimal. As a result, we are taking the step towards automation. We threw it.*
>
> *Batuhan: I took this coding and software course a lot in vocational high school. ...I really love coding. What can be done: You can directly bring out anything that is in your mind, you can make things happen, you can create them, and this has always seemed like a very attractive feature to me. When I started university, I started taking this computer programming course with the same excitement, but what I stumbled upon is something like this: When I was in high school, I was transferring all the codes to Arduino by copy paste. When I found it on the internet and started writing it here again, yes, I had a hard time at first, but then I gradually got used to all of them again.*

It has been observed that participants accelerate problem-solving processes through collaboration with peers, leading to more effective learning outcomes. Although simulation applications are designed to align with students' proficiency levels, the necessity of continuous development has been emphasized. Moreover, each problem-solving experience contributes to participants' ability to perform subsequent applications more efficiently and successfully.

Theme 4: Sense of Success

It is considered important for the participants to solve the problems they experience, get help from their friends, make new applications, see positive contributions to their professional development, and increase their professional competence with the experiences they gain. In this context, it is understood that the feeling that students experience when they succeed at each step is unique and that the participants continue to carry out the practices more willingly, being aware of this feeling. It has been stated that participation increases their cognitive development. It has been stated that the feeling of success experienced over time positively affects the sense of curiosity in the participants. It is understood that the students' motivation increased with the successful simulation results and the solution of the problems encountered during the simulation. It was also stated that the self-confidence of these participants increased. Some participant opinions regarding the theme are given below as direct quotes.

> *Batuhan: Teacher, I want to go with an example again. 2 weeks ago, while writing code for the SAT course at Aqua Florya with Kerem, we got stuck somewhere in the code, and I remember being happy like children in Aqua Florya when we found the solution to the code. That's why I think finding a bug in the code or fixing a bug is a real source of joy and a confidence booster. I think if I can do this, I can do something else too.*
>
> *Kerem: I am happy when I solve the problem, I mean we have accomplished the job, there is no problem, the system is working, everything is getting better, we are getting rid of stress, I think we can solve it even if we encounter such problems again.*
>
> *Selman: Sir, any problem we solve here gives us self-confidence. We gain self-confidence here. After solving a problem, that self-confidence affects the solution even if it has nothing to do with the issue. It has an impact on these issues.*
>
> *Ahmet: After graduated from vocational high school, I have worked for about seven years, I say using sensors through applications in this way corresponds to this in the workplace. In fact, during classes, if I cannot relate it myself, I sometimes ask my istructors. Since I was constantly focused on work while listening to the lecture, all of these applications are already the basis of many factory automation lines. Sensors, motors etc. All of these are applications that we can map to places in the workplace.*

The processes of problem-solving, peer support, and engaging in new applications play a vital role in participants' professional development. Experiencing success has been found to enhance motivation, positively influence curiosity, and strengthen self-confidence. The positive outcomes obtained through simulation applications encourage participants to engage in learning more willingly and with greater awareness.

Conclusion

Simulation software was preferred in the study for several reasons. These are (1) preventing the tools from deteriorating due to excessive level that may occur after incorrect connections in the work done by students, (2) not having the cost of purchasing physical tools or replacing the broken tools, (3) testing the possible and expected results in advance, (4) to prevent possible accidents or injuries; and (5) to be an alternative to a pandemic or geographical inability to come together. Based on the study data, it is concluded that the simulation software is used effectively among the students. When all data sources in the study were examined, many positive outcomes were observed in using simulation software to increase the quality of vocational education. It offers the potential to overcome environmental constraints, provides frequent training opportunities, instant feedback, and enables real-life experience in a simulated environment (Im, Gu, Lim & Lee, 2023; Liebermann & Erdelt, 2020). According to these results, the increase in the success level of the students throughout the process, the feeling of success due to the smooth operation of the applications and the positive attitudes towards professional skills make the study qualified.

It can be stated that the students' skills in the simulation software they use for the first time are at a good level. During the simulations, it was revealed that the problems arising from both the circuit connection and the coding phase were solved by the students. Simulation applications stand out as an effective tool for enhancing students' theoretical knowledge and practical skills (Chernikova, 2024; Koolivand et al. , 2024). Therefore, it can be stated that students' problem-solving skills have improved. It has been observed that students who are successful or have successfully completed the application help their peers. Moreover, research has shown that students' teamwork and communication skills have improved (Sezgin & Bektaş, 2023). It has been observed that these students show students who have problems how to solve the problem, inform them about the working principles of both software and circuit elements, teach and motivate them. It can be stated that since these students have more experience, debugging and opportunities to see different applications, their skill levels have improved more than other students. As a result of successfully completed applications, students' self-confidence increases.

Simulation software is used effectively to solve problems such as cost, danger and lack of experience. In order to ensure that students are at a high level of efficiency when using simulation software, it should be preferred that the applications be appropriate to the level of the students. With the adequate use of simulation applications, students' anxieties during the educational process can be reduced and learning environments can be improved (Jung et al. , 2012). Although there are some negative effects associated with the use of simulation applications in education, the overall conclusion highlights their strong and positive impact on educational outcomes (Zhonggen, 2023). Otherwise, it is possible that students will fail and therefore move away from the learning process. It was determined that some participants showed resistance during the implementation of the practices. These students may need to be motivated. Simulation software increases students' professional experiences. However, it will be a unique experience if these applications are carried out physically by the students. When it comes to real applications, the same number of applications may not be possible in a similar period of time, considering product supply and possible material damage.

The study revealed multiple positive outcomes of using simulation software in vocational education, aligning with findings from various academic sources. The increase in student achievement and the successful execution of applications, contributing to a sense of accomplishment, underscore the benefits of simulation-based learning (Gredler, 2004; de Jong & van Joolingen, 1998). The practical application of theoretical knowledge facilitated by simulations significantly enhances students' learning experiences, making them more effective and engaging (Kolb & Kolb, 2005; Brinson, 2015). Students displayed a high level of proficiency with the simulation software despite using it for the first time. This finding corroborates the research indicating that simulation tools can enhance technical skills and knowledge application in real-world scenarios (Cheng et al. , 2014; Cook et al. , 2013). The ability of students to resolve issues arising during circuit connections and coding processes demonstrates the development of problem-solving skills, a critical aspect highlighted in previous studies (Wouters et al. , 2013; Issenberg et al. , 2005). Additionally, simulation applications support the learning process by enhancing students' critical thinking skills and self-efficacy (Hall & Tori, 2017; Fey, 2014; Levett-Jones & Lapkin, 2014).

Peer assistance among students was observed, with more experienced students aiding those facing challenges.

This collaborative learning environment, facilitated by simulation software, promotes peer-to-peer teaching and reinforces learning, supporting findings by Schmidt, Rotgans, and Yew (2011). The opportunity for these students to engage in troubleshooting and diverse applications resulted in enhanced skill development compared to their peers, aligning with the concept of experiential learning (Kolb & Kolb, 2005). Successful completion of applications boosted students' self-confidence. This is consistent with research showing that positive reinforcement through successful simulation exercises can enhance self-efficacy and motivation (Johnson et al. , 2016; Lateef, 2010). Simulation applications are an effective teaching strategy that enhance students' confidence by allowing them to repeatedly practice their skills (Fegran et al. , 2023; Kim & Kim, 2017). The use of simulation software effectively addresses issues related to cost, danger, and lack of experience, providing a safe and economical learning environment (Anderson, 2008; Koehler & Mishra, 2009).

To ensure high efficiency in the use of simulation software, applications should be tailored to the students' proficiency levels. Failure to do so might lead to disengagement and decreased learning outcomes, a concern echoed in the literature (Means et al. , 2010; Selwyn, 2012). Additionally, the study noted resistance from some participants during the implementation process, indicating the need for motivational strategies to encourage full engagement (Tondeur et al. , 2017). Simulation software significantly enhances students' vocational experiences, yet physical implementation of applications provides irreplaceable hands-on experience. This aligns with the understanding that while simulations are beneficial, they should complement rather than replace physical practice (Gredler, 2004; Cheng et al. , 2014). The challenges associated with product supply and potential material damage in real-world applications emphasize the practicality and safety of simulations (Cook et al. , 2013; Issenberg et al. , 2005).

Highlighting the advantageous aspects of distance education and addressing identified shortcomings could enhance the quality of live courses delivered through distance education. Increasing interactivity and engagement in live sessions through interactive elements can foster participation and make sessions more dynamic (Hrastinski, 2008; Martin & Bolliger, 2018). Additionally, diverse teaching methods and multimedia resources should be used to avoid monotony and keep students engaged (Arbaugh & Benbunan-Fich, 2006; Garrison & Cleveland-Innes, 2005). Enhancing instructor preparedness through comprehensive training programs focusing on online teaching strategies and the use of digital tools is essential for improving technological proficiency and course delivery (Anderson, 2008; Koehler & Mishra, 2009). Continuous professional development and support should also be provided to help instructors adapt to evolving educational technologies (Tondeur et al. , 2017). Implementing these strategies will not only address the shortcomings identified in the study but also leverage the strengths of distance education to create a more engaging and effective learning environment.

The physical dimensions of simulation applications could be explored in greater depth for future studies conducted in this field. At this stage of research, physical outputs could be analyzed, and the effects of such applications could be investigated. Instructors' processes of monitoring and evaluating students' physical applications could be enhanced through the use of video recordings, which would allow for a more detailed analysis of student performance. Additionally, future research may explore methods to ensure the inclusion of students exhibiting resistance in the study.

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