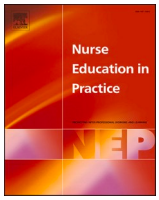
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Assessing the virtual reality perspectives and self-directed learning skills of nursing students: A machine learning-enhanced approach

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ABSTRACT

Aim: This study aims to investigate nursing students' perspectives on virtual reality technologies and their self-directed learning skills, specifically focusing on how these variables interact and influence each other in the context of nursing education. We also discern potential disparities in these skills based on descriptive characteristics, using both traditional statistical and advanced machine learning approaches for a comprehensive analysis.

Background: Rapid developments in technology, particularly during the Covid-19 pandemic, have brought virtual reality technologies to the forefront of nursing education. However, there is a gap in understanding how nursing students' perceptions of these technological relate to their development of self-directed learning skills.

Design: A descriptive and cross-sectional study design is employed to both quantify nursing students' perspectives on virtual reality in their education and assess their self-directed learning skills. This approach integrates traditional statistical methods with advanced machine learning techniques, with the intention of offering a comprehensive and nuanced analysis to inform future teaching strategies in nursing.

Methods: The study used a blend of survey scales and a tree-based machine learning model to measure and analyze nursing students' views, attitudes and self-directed learning levels. This dual approach allows for a more detailed assessment of the factors influencing self-directed learning abilities. Traditional statistical techniques were also applied to assess the reliability of the machine learning findings.

Results: Findings reveal that nursing students generally held positive views towards virtual reality technologies and exhibited a high level of self-directed learning skills. Notable differences in self-directed learning skills were influenced by gender on the overall scale ($p < 0.001$), with male students scoring higher than their female counterparts in both specific sub-dimensions and on the overall scale, but not by academic year. The machine learning analysis provided deeper insights into these variations, highlighting subtle distinctions in student demographics that traditional statistical methods did not fully capture.

Conclusions: The study offers valuable insights into interconnected nature of nursing students' views on virtual reality technologies and their self-directed learning skills. The results support the integration of virtual reality in nursing curriculum programs and underscore the importance of customizing teaching strategies based on insights gained from machine learning analyses. This approach has the potential to substantially improve both the learning experience and the overall quality of nursing education.

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1. Introduction

Advancements in technology during the 21st-century have profoundly influenced individuals, healthcare professions and societies, having an impact on various aspects of life (Sarıkoç, 2016; Adib-Hajbaghery and Sharifi, 2017; Gedik, 2020; Goktas et al., 2023). Notably, the rapid progress in information and communication technologies, particularly in healthcare and education, has necessitated a shift from traditional teaching methods to more innovation approaches. The Covid-19 pandemic has significantly accelerated the adoption of these innovative methodologies in the nursing profession, including virtual learning, virtual simulation and virtual reality applications. This shift has been particularly evident among tech-savy (or new generation) Millennial and Gen Z nursing students (Şenyuva, 2019). Consequently, students, educators and instructors have been required to adapt to these advancements, embracing new ways of teaching and learning (Ulupınar and Toygar, 2020).

In our today's world, advanced technologies are crucial for meeting the changing needs of emerging healthcare. This understanding is especially important in the context of evolving medical education, particularly in nursing, where the integration of technology can potentially transform teaching methodologies and prepare new generation students for future healthcare challenges. For this reason, the use of virtual reality in nursing education has the potential to shape and improve the self-directed learning abilities of nursing students. We need to prepare them for the complexities of evolving healthcare trends, ensuring they have the necessary skills and knowledge related to emerging healthcare technologies.

Recent global developments, notably the Covid-19 pandemic, have posed challenges in nursing education, such as insufficient nursing practice leading to student anxiety in clinical settings. To address these challenges, it has become crucial to prepare future implementations, equipping future generations of nurses with advanced technological tools. The integration of innovative technologies like virtual reality, virtual simulation, artificial intelligence and the Internet of Things has provided valuable learning opportunities in nursing education (Bodur and Kaya, 2017; Bodur et al., 2019; Şahin and Başak, 2022). We expand on the rapid advancements in healthcare technology, particularly emphasizing the increasing relevance and application of virtual reality in nursing education. These technological advancements necessitate an adaptation in learning methodologies among nursing students, with virtual reality playing a pivotal role in this transition.

Virtual reality simulations, with their ability to create lifelike experiences through enhanced sensory interactions, have become particularly appealing to Generations Y and Z (Bayram and Çalışkan, 2021; Kaya and Karaman, 2022; Kılınç and Uzun, 2022). It stimulated all sensory perceptions with its immersive and interactive features, mimicking real-world environments without the need for expensive resources or exposure to hazardous conditions. Additionally, it allowed nursing students to practice procedures they might not have encountered in clinical settings.

The prevalence of tech-savvy nursing students and the influence of gaming on learning preferences had amplified the use of virtual simulations and reality in nursing education, a trend intensified by the Covid-19 pandemic (Morin, 2020; Kim et al., 2021; Rim and Shin, 2022; Saab et al., 2021). These tools offered an immersive, student-centred environment, fostering active involvement, multi-sensory stimulation and improved learning outcomes (Dutucu et al., 2022; Hwang et al., 2022; Tuna and Özkan, 2022; Plotzky et al., 2021; Joung and Kang, 2022; Yu and Yang, 2022; Zeng et al., 2022). Despite the emergence of virtual reality integration in Turkish simulation labs, studies on its implementation in nursing education remained limited, both globally and in Turkey. Nevertheless, there is an emerging trend to integrate technologies such as machine learning (ML), deep learning and virtual reality into the nursing curriculum. This trend is driven by the recognition that these advanced technologies can significantly enhance the educational experience, providing nursing students with tools and methodologies that are increasingly relevant in emerging healthcare settings (Jeong and Lee, 2019).

Our study aims to fill this gap by exploring nursing students' perspectives on virtual reality technologies and their self-directed learning skills. The study focuses on both virtual reality technologies and self-directed learning skills due to their growing significance in nursing education and potential synergistic effects on student learning. This justification highlights the need to explore the impact of these variables in conjunction, considering their increasing importance in the nursing curriculum. Traditional research methodologies, while providing valuable insights with descriptive statistical methods, often fall short in capturing the complexity of self-directed learning in the context of evolving technologies. In this context, the application of ML offers a new dimension in educational research. By analyzing complex datasets, ML can uncover patterns and insights that traditional statistical methods might miss, particularly in understanding how technology influences learning. Therefore, we employ a ML approach alongside traditional statistical methods to provide a more nuanced analysis. The use of ML in this study is not just a tool but a crucial component in providing a more nuanced analysis, allowing for the identification of intricate patterns and relationships among variables using specific survey scales.

In our research, we synergize ML and traditional statistical methods to conduct an in-depth analysis of self-directed learning skills among nursing students. This comprehensive approach takes into account various factors, including gender and academic year of study and focuses on the capacity of a ML model to effectively discern and interpret patterns with these skills. Our objective is to gain a thorough understanding of the influence of virtual reality and virtual simulation experiences on the development of self-directed learning competencies in nursing education. The study is expected to contribute novel insights into the integration of virtual reality in nursing education, particularly in enhancing self-directed learning skills among nursing students.

The overarching goal of our research is to contribute to the advancement of nursing education curricula, addressing student needs and effectively integrating virtual reality technology into educational programs. Our study is driven by the following key research questions:

- What are the perspectives of nursing students regarding virtual reality technologies in their educational contexts?
- What levels and sub-dimension of self-directed learning skills are exhibited by nursing students?
- Do these self-directed learning skills vary among nursing students based on factors such as gender, academic year and other descriptive characteristics?
- How effectively can a machine learning model reveal and interpret changes or patterns in the self-directed learning skills among nursing students?

2. Methods

2.1. Design

This is an analytical, descriptive and cross-sectional study conducted to analyze nursing students' perspectives on virtual reality in nursing education and their self-directed learning skills.

2.2. Settings and study population

The study population comprised undergraduate nursing students from all years of study, who were enrolled at Istanbul universities during the 2021–2022 academic year. They were also members of the Student Nurses Association and the Istanbul Chapter of the Turkish Nurses Association's Student Commission (N: 11,000) (Accessed on September 19, 2023, from https://ohder.org.tr/ and https://www.thder.org.tr/biz-kimiz), were invited to participate in the study. Although

participation was voluntary, the sampling method aimed to select individuals who were actively engaged in their professional community, thus representing a purposive sampling strategy. We also prioritized those studying in cosmopolitan Istanbul, who came from all over Turkey. The study, conducted during the Covid-19 pandemic, included 309 nursing students who volunteered to participate.

2.3. Data collection

Data were collected from January to April 2022 via an online survey on Google Forms, which participants voluntarily completed. The survey was approved by the university's ethics committee and participants confirmed their consent before beginning. Due to the Covid-19 conditions, data collection occurred during non-school hours, using connections via the Student Nurses Association in Istanbul and social media platforms. The survey took approximately 15 minutes to complete.

2.4. Instrument

Two tools were employed for data collection: an "Information Form" and a "Virtual Reality Visual Analog Scale (VAS)" developed by the researchers in accordance with the literature (Sarman et al., 2021; Şen et al., 2022), as well as the "Self-Directed Learning Skills Scale" developed by Tekkol and Demirel (2018).

2.4.1. Information form

The researchers used a literature-based information form (Şen et al., 2022) to collect nursing students' sociodemographic details. This form inquiry about their age, gender, academic year, university type, residence, access to technological tools and internet, experience with virtual games, daily smartphone usage, familiarity with virtual reality and views on its implementation in nursing.

2.4.2. Virtual reality visual analog scale (VAS)

The VAS, informed by the existing literature (Sarman et al., 2021; Şen et al., 2022), consisted of 31 items designed to ascertain students' perspectives towards virtual reality technology. We acknowledge the lack of established validity and reliability for this specific scale in the literature; hence, we conducted a pilot study with 30 university students to ensure its applicability and made necessary adjustments based on the feedback. On the scale, participants were asked to rate each item on a scale from 0 (I disagree) to 10 (I strongly agree). Due to a lack of valid and reliable scale in the existing literature concerning perspectives on virtual reality technologies, the researchers, guided by the literature, developed this VAS without performing any psychometric analyses (Sarman et al., 2021; Şen et al., 2022). Only Cronbach's alpha value of the VAS scale was calculated as 0.958 for the sample group.

2.4.3. Self-directed learning skills scale

The validity and reliability of the scale for the Turkish context were assessed by Tekkol and Demirel (2018). We have used the term '*self-directed learning scale*' consistently throughout to align with the scale's established validity and reliability. Internal consistency reliability of the sub-dimensions of the scale was evaluated, yielding a Cronbach's alpha of 0.867, indicating good reliability. The scale used a five-point Likert-type scale format, ranging from "Never", to "Always". The scale had a minimum possible score of 21 and a maximum of 105. It was divided into four sub-dimensions: ***motivation*** (7 items), ***self-monitoring*** (5 items), ***self-control*** (5 items) and ***self-confidence*** (4 items). Together, these factors collectively explained 52.906% of the total variance associated with the scale. The total internal consistency coefficient of the scale was calculated to be 0.895.

2.5. Methodological strengths and limitations

Due to the Covid-19 pandemic and the resulting shift to remote education, we collected data through electronic means. This methodological approach made it difficult to maintain consistent contact with the nursing students in our study sample. The lack of proven validity and reliability for the "Virtual Reality Technologies Visual Analog Scale" along with the timing of the study during the Covid-19 pandemic period, limited the generalizability of the data. The results of this study were limited to the nursing students who participated in the sample.

2.6. Ethical considerations

Ethical approval for the research was obtained from the Social and Human Sciences Research Ethics Committee of the university (Decision no. 2022/77, Dated: April 12, 2022). We adhered to the principles of the Helsinki Declaration throughout the research process. Students were included in the study by selecting the "I agree to participate in the study" option at the beginning of the data collection form. We obtained permission to use the scale in the study via email from the authors who had conducted the validity and reliability studies in Turkish.

3. Data analysis

3.1. Traditional statistical analysis approach

We used IBM SPSS Statistics (IBM Corp., Armonk, NY, USA) version 28.0 for data analysis. Continuous variables were represented as mean and standard deviation, while categorical variables were presented as frequency and percentage. To assess the self-directed learning scale, we conducted a one-way ANOVA test to compare the average scale scores of students across different classes. The Bonferroni Post Hoc test was employed to identify the specific source of differences. The Student t-test was used to examine statistically significant differences in mean scale scores based on students' gender. We used Pearson correlation test and performed reliability analysis using Cronbach's alpha coefficient. The significance level was set as $p < 0.05$ for all comparisons (Chan, 2003).

3.2. Employing tree-based machine learning to evaluate factors influencing self-directed learning in nursing education

In this study, we employed a Random Forest classifier, a tree-based ML method, to identify significant factors influencing nursing students' self-directed learning skills in virtual reality contexts. This comprehensive methodology is depicted as a schematic overview (See details in Fig. 1). The Random Forest model, an ensemble learning method that constructs multiple decision trees and integrates their outcomes to improve prediction accuracy, is known for handling non-linear relationships and complex interactions between variables effectively (Breiman, 2001). Given these attributes, it was an optimal choice for our research. We partitioned the dataset into predictor (X) and target (y) variables, reserving 30% of the data for testing using '*train_test_split*' from the '*sklearn.model_selection*' module. Our model was constructed using *RandomForestClassifier* utility, with 10 estimators and '*balanced_subsample*' as the class weight. We validated the model using 10-fold cross-validation and measured its performance through mean cross-validation scores and accuracy. Feature importance analysis helped identify crucial factors affecting the target — nursing students' self-directed learning skills. The results were analyzed using Python version 3.9.1 and scikit-learn version 1.1.1 and visualizations were created with Matplotlib.

4. Results

The study examined the sociodemographic characteristics of nursing students and found an average age of 19.5 years, with most being females (76.4%). Most of the participants were enrolled in a public university (81.6%), with the largest proportion being third-year students (39.5%) and most resided in dormitories (57.9%). Technology-wise,

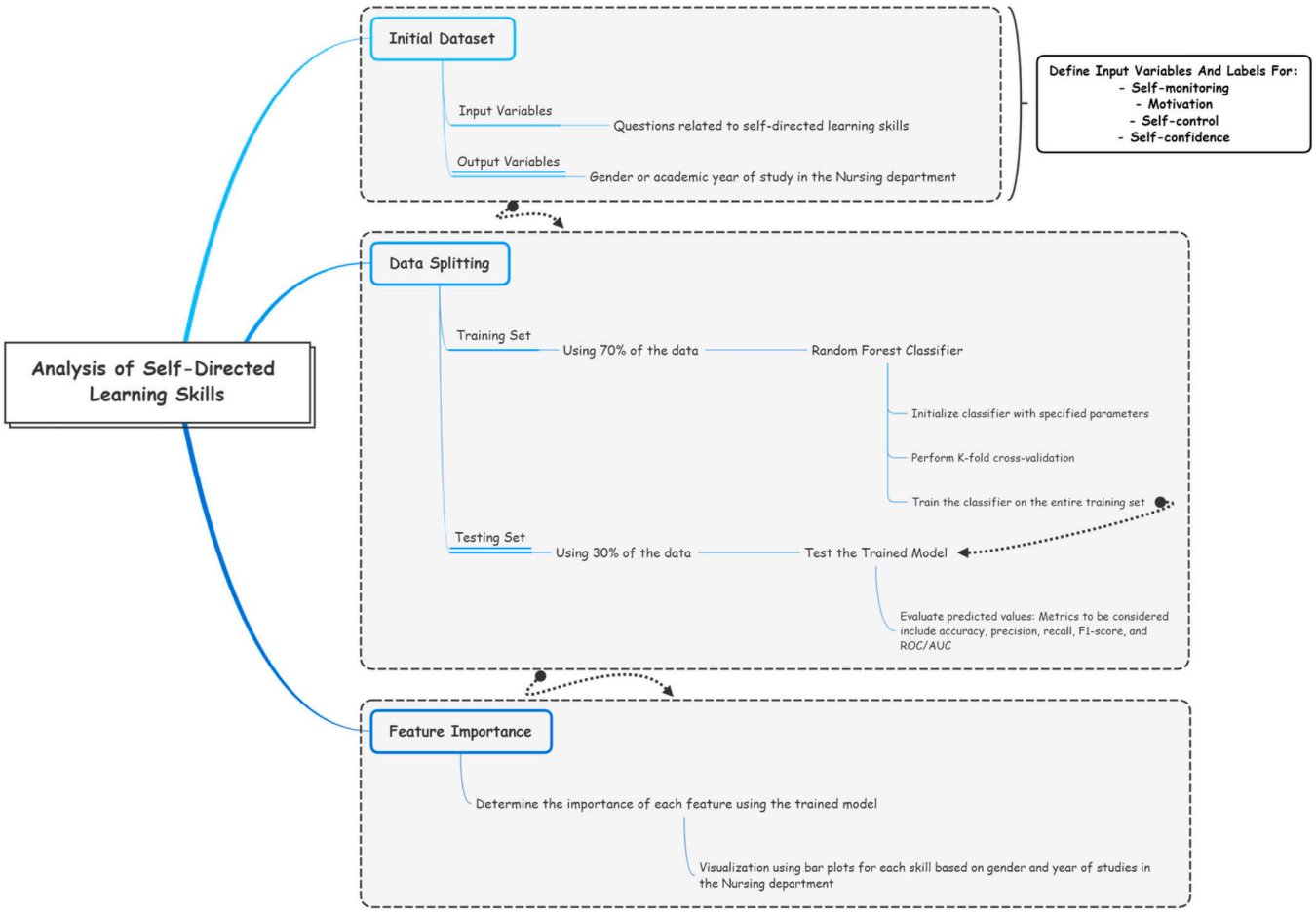


Fig. 1. A systematic overview detailing the process of analyzing self-directed learning skills using the Random Forest classifier. The illustration encompasses stages from initial dataset creation to final visualization, capturing data handling, model training, evaluation and interpretation steps.

nearly all had access to devices such as computers or phones (98.1%) and internet connectivity (99.4%). While a substantial percentage had experience playing virtual computer games (75.7%), over half (55.3%) reported no prior experience with virtual reality. Moreover, 71.8% indicated limited knowledge about the application of virtual reality in nursing, although 88.7% believed that the using virtual reality technology in nursing education would be beneficial (Table 1).

4.1. Nursing students' perspectives on virtual reality technologies

The study investigated nursing students' views on virtual reality technologies and revealed a spectrum of opinions. The results showed that the item "*I believe virtual reality technology will assist in concretizing subjects*" scored highest on the Virtual Reality Visual Analog Scale (VAS) (8.21 ± 2.16). This high score suggested that students strongly believe in the benefits of virtual reality. Thus, they view virtual reality technologies as a valuable tool that highlight the potential for in-depth learning experiences through visual and auditory learning styles, enabling theoretical topics in nursing to be embodied in practice. Furthermore, students expressed a positive inclination towards the use of three-dimensional visuals in virtual reality technology during their classes, evidenced by a high average score for the statement "*I would enjoy the use of three-dimensional images in virtual reality technology during lessons*" (8.21 ± 2.14). This suggested that students appreciate the integration of three-dimensional elements in virtual reality, considering it advantageous for their learning process.

Additionally, a substantial number of students expressed their belief in the effectiveness and efficiency of virtual reality as a learning method, demonstrated by high average scores for the statements "*I believe virtual reality will provide effective and efficient learning*" (8.11 ± 2.22) and "*I believe virtual reality technology will provide a flexible learning environment (accessible anytime, anywhere)*" (8.06 ± 2.21). This highlighted students' trust in virtual reality's capacity to facilitate a more engaging and meaningful educational experiences.

Conversely, the item that scored lowest among nursing students was "*I believe virtual reality technology cannot be used in nursing education*" (3.89 ± 2.87), revealing some scepticism or uncertainty within a segment of the student population. Similarly, the statement "*I believe virtual reality will be distracting*" also had a relatively lower average score (4.09 ± 2.71), suggesting concerns about potential distractions or

Table 1
Perspectives of nursing students regarding technological advancements (N: 309).

Perspectives	Yes	No
	# %	# %
Do you have technological devices like computers/phones in your place of residence?	303% **98.1**	6%1.9
Do you have internet connectivity in your place of residence?	307% **99.4**	2%0.6
Have you previously played virtual computer games?	234% **75.7**	75% 24.3
Have you experienced virtual reality before?	138% 44.7	171% **55.3**
Do you think you have knowledge about virtual reality applications in nursing?	87% 28.2	222% **71.8**
Do you think the use of virtual reality technology in nursing would be beneficial?	274% **88.7**	35% 11.3

disadvantages associated with the use of virtual reality.

These findings shed light on nursing students' attitudes toward virtual reality technologies in the context of nursing education. Educators and institutions should consider these perspectives while incorporating virtual reality into nursing curricula, addressing any concerns and ensuring its effective integration for optimized learning outcomes (see Table 2 for more details).

Table 2
Views of nursing students on virtual reality technologies (N: 309).

Statements	X ± SS
1. I consider my knowledge about virtual reality sufficient.	5.39 ± 2.61
2. I believe that I have sufficient information about virtual reality technology in nursing education.	4.64 ± 2.24
3. I think virtual reality is attractive to students.	7.82 ± 2.06
4. I believe virtual reality would encourage me towards active learning.	7.77 ± 2.08
5. I believe virtual reality will help students with a visual learning style.	7.96 ± 2.04
6. I think virtual reality will assist students with an auditory learning style.	7.69 ± 2.07
7. I believe virtual reality will aid students with a tactile learning style.	7.38 ± 2.36
8. I think virtual reality will facilitate the integration of my theoretical knowledge with practice.	7.86 ± 2.08
9. I believe virtual reality will minimize medical and professional errors.	7.68 ± 2.09
10. I believe virtual reality technology is necessary in nursing education.	7.89 ± 2.11
11. I think virtual reality technology will facilitate learning for new generations.	7.97 ± 2.05
12. I believe virtual reality technology could be beneficial in terms of repeatability.	7.95 ± 2.08
13. I believe that virtual reality technology will have negative effects on human health.	4.35 ± 2.32
14. I believe that nursing students need to have direct contact with patients and the hospital environments.	6.78 ± 2.48
15. I would like virtual reality technology to be used in our future lessons.	8.04 ± 2.22
16. ***I would enjoy the use of three-dimensional images in virtual reality technology during lessons.***	***8.21 ± 2.14***
17. I believe that virtual reality technology will create a sense of reality.	7.89 ± 2.19
18. ***I believe virtual reality technology will assist in concretize subjects.***	***8.21 ± 2.16***
19. I believe virtual reality technology will be beneficial in my individual studies.	7.99 ± 2.16
20. I believe virtual reality technology will increase my interest in the lesson.	8.05 ± 2.13
21. I believe virtual reality technology will provide a flexible learning environment (accessible anytime, anywhere).	8.06 ± 2.21
22. ***I believe virtual reality will provide effective and efficient learning.***	***8.11 ± 2.22***
23. I believe virtual reality will boost my learning motivation.	8.01 ± 2.13
24. I believe that virtual reality is unnecessary in education.	3.81 ± 2.74
25. I believe virtual reality will be distracting.	4.09 ± 2.71
26. I think it would be more beneficial for students to learn intravenous interventions and all skill training in a virtual environment.	6.54 ± 2.77
27. I believe it will be important for students to experience their psychomotor skills in a virtual environment for the safety of patients and students.	7.70 ± 2.22
28. I think solving example cases/issues with virtual reality technology will be a more lasting learning method for students.	7.79 ± 2.26
29. I believe it would contribute more to the students to easily repeat after theoretical education with virtual reality technology.	7.94 ± 2.16
30. I would like to use virtual reality technology via virtual simulations that can provide instant feedback.	7.98 ± 2.20
31. I believe that virtual reality technology cannot be used in nursing education.	3.89 ± 2.87

X represents the average score and SS represents the standard deviation for the corresponding statement.

4.2. Evaluating self-directed learning skills in nursing students through traditional statistical techniques

In the assessment of the self-directed learning abilities among nursing students, the collective score was 90.77 ± 8.93 on the overall scale. Their scores in the various sub-dimensions were as follows: 20.30 ± 2.26 in self-monitoring; 31.18 ± 3.06 in motivation; 20.67 ± 2.87 in self-control; and 17.61 ± 2.27 in self-confidence. The data indicated a high level of proficiency in self-directed learning skills among the participants. The reliability of the scale used in the study was confirmed with the Cronbach's alpha internal consistency coefficient, resulting in a score of .867. Similarly, the sub-dimensions showed acceptable to good internal consistency, with values ranging from .762 (for Motivation) to .805 (for Self-Confidence). These findings suggest that the scale and its sub-dimensions reliably measure the construct of self-directed learning among nursing students (See Table 3 for more details).

When evaluating the impact of gender on self-directed learning skills, males significantly outperformed their female counterparts overall ($p < 0.001$). Although no significant differences were observed across class levels as a whole, notable variations were found in the self-confidence and self-control sub-dimensions, particularly fourth-year students (Table 4). These findings suggest that the accumulation of experience and knowledge over their academic careers may enhance self-confidence and self-control in self-directed learning.

Interestingly, aside from fourth-year students, no significant differences were observed across class levels in the sub-dimensions of self-confidence and self-control. The scores of first-, second- and third-year students in the domains of self-monitoring, motivation, self-control, self-confidence and the overall scale did not reveal substantial differences. This lack of variation suggests that the evolution of these self-directed learning skills may not directly correspond with the academic progression, possibly hinting at the influence of other factors in their development.

4.3. Machine learning approach to assess self-directed learning skills in nursing students

In a more detailed analysis using a tree-based ML approach, we examined the importance scores of various features affecting self-directed learning skills among nursing students. This approach provided us a comprehensive understanding of how various aspects of self-directed learning were influenced by both gender and academic year of study. The goal was to identify the most and least influential factors contributing to these learning skills, thereby enhancing our ability to understand and potentially improve these capabilities among nursing students (See Table 5 for more details).

Regarding gender-based evaluation, the most significant feature influencing self-monitoring skill was the students' ability to clearly define their learning objectives (*Q3*: "*I clearly set out my learning objectives*"), with a feature importance score of 0.302. Conversely, the least influential feature was their practice of reviewing goal attainment at the end of the learning process (*Q7*: "*I check the level of my goal attainment at the end of the learning process*"), which had a score of 0.157. Motivation, on the other hand, was most significantly influenced by the students' desire for lifelong learning (*Q17*: "*I want my learning process to continue throughout my life*") and least affected by their enthusiasm for learning new things (*Q13*: "*Learning new things is exciting*"). Self-control was mainly influenced by their regular reviews of the learning process (*Q9*: "*I regularly review my learning process*"), but least influenced by the use of diverse learning strategies (*Q16*: "*I benefit from different learning strategies*"). Lastly, self-confidence was most influenced by self-perceived competency over the opinions of others (*Q5*: "*What's important is not others finding me competent, but my finding myself competent*"), whereas the least influential aspect was their sense of responsibility in identifying

Table 3
Average scores of self-directed learning skills and Cronbach's alpha internal consistency values for nursing students.

Scale and Sub-dimensions	Minimum	Maximum	Average	Standard deviation	Cronbach alpha internal consistency values
Self-directed learning scale	29.00	105.00	**90.77**	**8.93**	**0.867**
• **Self-monitoring**	9.00	25.00	20.30	2.26	0.789
• **Motivation**	11.00	35.00	31.18	3.06	0.762
• **Self-control**	5.00	25.00	20.67	2.87	0.794
• **Self-confidence**	4.00	20.00	17.61	2.27	0.805

Table 4
Comparison of self-directed learning skills of nursing students based on descriptive statistics through traditional statistical techniques.

Variables	Study groups	Self-monitoring		Motivation		Self-control		Self-confidence		Overall scale score	
		X	SS	X	SS	X	SS	X	SS	X	SS
Gender	Female (N: 236)	21.15	2.34	30.90	3.19	20.30	2.90	17.36	2.41	89.72	9.31
	Male (N: 73)	21.78	1.91	32.09	2.39	21.89	2.42	18.42	1.45	94.19	6.53
	Test	$t = -2.073$		$t = -2.933$		$t = -4.244$		$\boldsymbol{t = -3.565}$		$t = -3.816$	
	$p =$	***0.023****		***0.004****		***0.000****		***0.000****		***0.000****	
Years of studies in nursing department	First-year (N: 89)	21.19	2.29	30.84	3.08	20.60	3.00	16.73	2.45	89.37	9.18
	Second-year (N: 122)	21.31	1.98	30.89	2.75	20.16	2.57	17.95	1.90	90.32	7.70
	Third-year (N: 64)	21.71	2.69	31.70	3.55	21.35	3.15	17.92	2.55	92.70	10.67
	Fourth-year (N: 34)	20.79	2.17	32.17	2.88	21.41	2.66	18.08	1.83	92.47	8.25
	Test	$F = 1.375$		$F = 2.573$		$F = 3.334$		$F = 6.661$		$F = 2.265$	
	$p =$	0.251		0.054		***0.020****		***0.000****		0.081	

X represents the average score and SS represents the standard deviation for the corresponding statement.
* indicates a statistically significant difference with a p-value less than 0.05.

Table 5
Machine-learning comparative analysis of self-directed learning skills among nursing students based on gender and year of studies in the nursing department. The table illustrates the most and least significant feature scores for Self-monitoring, Motivation, Self-control and Self-confidence in these groups, as identified by the tree-based machine learning model.

Variables	Factors	Most Importance Feature (Scores)	Least Importance Feature (Scores)
Gender	Self-monitoring	Q3 (0.302)	Q7 (0.157)
	Motivation	Q17 (0.249)	Q13 (0.074)
	Self-control	Q9 (0.362)	Q16 (0.117)
	Self-confidence	Q5 (0.332)	Q11 (0.165)
Year of Studies in Nursing Department	Self-monitoring	Q1 (0.276)	Q18 (0.154)
	Motivation	Q6 (0.221)	Q2 (0.087)
	Self-control	Q9 (0.323)	Q16 (0.104)
	Self-confidence	Q15 (0.268)	Q19 (0.222)

learning gaps (*Q11*: "*Identifying my learning deficiencies is my responsibility*").

In the evaluation based on academic years, the factor for self-monitoring with the most impact was the students' ability to identify what learning is needed to solve a problem (*Q1*: "*When faced with a problem, I determine what I need to learn to solve that problem*"). The factor with the least impact was the ability to recognize their own learning needs (*Q18*: "*I identify my learning needs*"). In terms of motivation, the belief that time spent on learning is not wasted (*Q6*: "*I believe that the time spent on learning will not be wasted*") had the highest influence, whereas the least significant was viewing new situations as opportunities for learning (*Q2*: "*A new situation encountered is an opportunity for learning*"). Like in the gender-based evaluation, self-control was most affected by regular reviews of their learning process (*Q9*) and least by the use of different learning strategies (*Q16*). Self-confidence was predominantly influenced by the ability to self-criticism to enhance learning (*Q15*: "*Criticizing myself enables me to learn better*"), while the least influential was their responsibility for learning-related decisions (*Q19*: "*I am responsible for my decisions related to learning*").

Our ML analysis, illustrated in Fig. 2, provides a nuanced understanding of feature importance scores, complementing the traditional statistical interpretations presented in Table 4. For instance, although traditional statistical methods showed gender-based differences in Self-monitoring, ML analysis further clarified that both genders attributed the highest importance to *Q3* — a crucial aspect of Self-monitoring. This additional insight could potentially explain the observed statistical significance. Conversely, *Q7*, which has the lowest importance score in ML approach, may not be as distinguishing between genders. Similarly, in terms of academic year, ML revealed that elements like *Q1* might indeed vary across academic years among nursing students, even though traditional statistics did not show a significant difference in Self-monitoring.

5. Discussion

The study's findings predominantly involved second-year female students from a public university, with an average age of 19.5. As expected from their generational characteristics, these students were well-equipped with technology and had reliable internet access. These factors are crucial in understanding their receptiveness to virtual reality in nursing education, suggesting a likely positive adoption of such technologies.

While most students had experience with virtual computer games, their specific exposure to virtual reality in a nursing education program was limited. They identified a knowledge gap regarding the role of virtual reality in nursing education but believed in its potential benefits, as indicated in Table 1. Virtual reality applications, which enhance the understanding of complex concepts through visual models, are increasingly being adopted in educational settings (Aydın and Şahin, 2021). This acknowledgment of a knowledge gap yet positive attitude towards virtual reality underscores the need for integrating such technologies in nursing education, aligning with existing literature that points to Generation Z's readiness for technological innovations in educational settings (Hernandez-de-Menendez et al., 2020; Kuleto et al.,

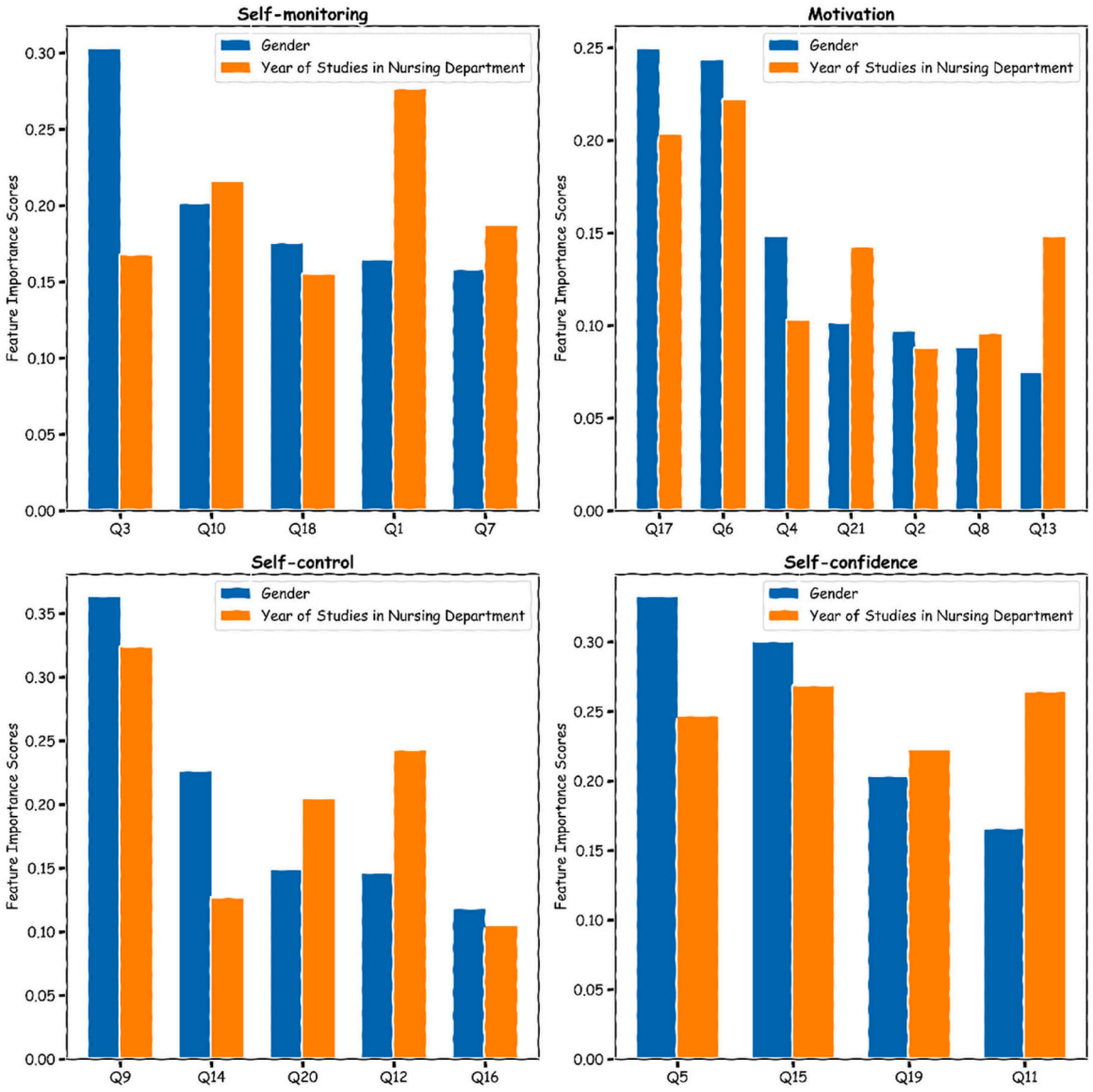


Fig. 2. Machine learning-based comparative assessment of importance scores for self-directed learning skills in nursing students, segmented by gender and academic year. The four skills – Self-monitoring, Motivation, Self-control and Self-confidence are evaluated based on specific questions (Q#). Each bar chart visually illustrates the degree to which these specific questions contribute to shaping the respective skills among both genders and across various academic years in the nursing program.

2021).

In virtual classroom settings, educators can significantly enhance student learning by promoting exploration and guiding students through their learning journey (Tepe et al., 2016), aligning with Kolb's experiential learning theory. This theory, which emphasizes the effectiveness of engaging, reflecting, understanding and applying, can be adeptly applied to virtual environments, including virtual reality. Such adaptability of Kolb's theory allows for customizing of learning experiences to individual student preferences, fostering more adaptable and versatile in their learning journey (McLeod, 2017). Our study showed that nursing students hold positive attitudes toward virtual reality, particularly appreciating the use of three-dimensional imagery in education. This preference suggests that such technology could make academic subjects more accessible and engaging, especially for the newer, technologically adept generations.

The Covid-19 pandemic' shift to remote education brought challenges but also accelerated the adoption of innovative teaching technologies in nursing education. Despite the traditional in-person approach in Turkey's nursing education, constraints such as staff shortages, rising student numbers and limited practical spaces led to the integration of virtual reality into clinical practice and skills training. This technology has been instrumental in safely teaching procedures such as pelvic exams, nasotracheal aspirations, urinary catheterizations, cardiopulmonary resuscitation (CPR) and intravenous (IV) catheterization to apply knowledge effectively without compromising patient safety (Jallad and Işık, 2022). Despite the challenges of the Covid-19 pandemic, nursing students in our study continued their education, showcasing high digital literacy and a tendency towards game-based learning, typical of Generation Z (Table 1). Our study investigated their views on self-learning through virtual reality technologies and their self-directed learning abilities. The findings indicated a high level of self-directed learning abilities among these students, characterized by higher motivation and relatively lower self-confidence scores (Table 3).

Previous studies align with our findings, demonstrating varying levels of self-directed learning readiness among nursing students. Sarmasoğlu and Görgülü (2015) confirmed a satisfactory readiness level, while Yılmazsoy and Kahraman (2019) observed above-average skills in university students engaged in remote education. Similarly, Recepoğlu's

(2021) found a positive perception of self-directed learning among teacher candidates, with motivation scoring the highest ($r = 4.28$) and self-control the lowest ($r = 3.62$). Contrasting these, Karagülle and Berkant (2022) and Hasgören and Güvercin (2023) reported more moderate levels of these skills, particularly during the pandemic. Teke (2020) noted that self-directed learners tended to exhibit specific characteristics, such as curiosity, motivation, willingness to take responsibility for learning, advanced communication skills and the ability to self-evaluate. Collectively, these studies suggest that self-directed learning skills among students can vary significantly, influenced by factors such as learning environment and teaching methodologies.

Our analysis uncovered notable gender differences in self-directed learning skills, with males scoring higher overall ($p < 0.001$, Table 4). This finding prompts a deeper exploration of gender dynamics in nursing education, particularly in the context of technology integration and self-directed learning. Although the cessation of gender discrimination in Turkish nursing in 2007, as announced in the Official Gazette, under the title "Amendment to the Nursing Law" (Official Gazette, Issue: 26510, April 5th, 2007, Law No: 5634; Retrieved from https://www.resmigazete.gov.tr/eskiler/2007/05/20070502–3.htm), may have fostered an environment conductive to higher scores in self-confidence, self-control and motivation among male students in our study, it is crucial to explore a broader spectrum of factors. Rajacich et al. (2013) highlighted the unique challenges and stereotypes faced by male nurses, suggesting that navigating these challenges could influence male nursing students' scores. Noordien et al. (2020) further provided insights into the specific motivations of male students choosing nursing, which might suggest a leaning towards specific parts of the profession. Furthermore, recent studies, including one by Salamonson et al. (2023), indicated that gender disparities still existed in the nursing field. This suggested that the high scores among male nursing students might have been influenced by other elements, potentially including differences in tech-related questions or clinical placements.

Contrasting findings from other researchers, such as Yılmazsoy and Kahraman (2019) and Artsın et al. (2020), indicated a complex interplay of factors affecting gender-based differences in self-directed learning. Previous research by Yılmazsoy and Kahraman (2019) found significant gender-based differences in the motivation sub-factor of the scale among university students involved in remote education. Another study by Artsın et al. (2020), which involved students enrolled in an online university course, observed gender-dependent differences in self-directed learning skills, with females demonstrating higher skills than males. However, according to studies by Karagülle and Berkant (2022), Baykan et al. (2023) and Park et al. (2023) involving university students, there were no significant gender-based differences in the sub-categories of self-monitoring and self-control. Interestingly, in our study, a notable trend emerged where male students outperformed female students in terms of motivation, self-confidence and overall scores. However, it is interesting to note that, across the board, the lowest average scores were in motivation, while the highest were in self-control. These findings suggest a complex interplay of gender dynamics in education and the nursing profession, indicating that male and female students may experience and respond to the learning environment differently, particularly in areas like motivation and self-control.

Furthermore, in our traditional statistical analysis, when comparing self-directed learning skills based on the academic year of study in the nursing program, there was no statistically significant difference overall. However, a significant disparity was noted in the sub-dimensions of self-confidence and self-control. It was satisfying to note that fourth-year students exhibited significantly higher levels of self-confidence and self-control compared with their colleagues in other years (Table 4). According to a study conducted by Tekkol and Demirel (2018) among university students, the average self-directed learning skill scores of first-year and fourth-year students showed little difference, with no statistical significance. Similarly, Sümen and Evgin's (2022) research with nursing students found no notable variation between different years of study. Through our study, an interesting observation was made: all students, regardless of year level, had engaged in remote education during the Covid-19 pandemic. This might have contributed to the development of their self-directed learning skills uniformly across all years. Alternatively, the results could suggest that self-directed learning skills are not only dependent on formal education. Individuals might have managed their self-learning skills through informal educational experiences.

In synthesizing these observations with the employment of a tree-based ML approach, our study offers a unique perspective on how self-directed learning skills are influenced by and interact with students' engagement with virtual reality. This in-depth investigation aimed to understand the impact of gender and academic year on these aspects and to identify the key elements, presenting a novel approach beyond traditional statistical analysis in the existing literature. Through the use of ML, we transformed detailed insights into interpretable data, aiding in the formulation of effective strategies to enhance self-directed learning skills. This method offered a significant edge over traditional statistical methods by revealing patterns or nuances otherwise hidden in the data, highlighting specific areas in the survey that required emphasis to boost nursing students' self-directed learning skills.

Our ML-based gender-specific assessment indicated that clearly defining learning objectives was the most influential factor for developing self-monitoring skills (Fig. 2 and Table 5). However, reviewing goal attainment at the end of the learning process was the least influential. In terms of motivation, we found that students were primarily driven by an aspiration for lifelong learning; however, this did not necessarily translate into short-term enthusiasm for learning new things or knowledge. Regarding self-control, regular self-assessment of the learning process was the most influential, while the use of varied learning strategies had minimal impact. The predominant factor in forming self-confidence was students' self-perceived competence, which surpassed the opinions of others, while identifying learning gaps held the least influence.

When examining the influence of academic years using the machine learning approach (Fig. 2 and Table 5), it was found that the most critical factor in self-monitoring was students' capacity to determine what they need to learn to solve specific problems. Conversely, the least influential factor was their ability to identify general learning needs. For motivation, the belief that time spent on learning was never wasted emerged as the most influential factor, whereas viewing new situations as opportunities for learning was the least significant. Self-control, similarly to the gender-based evaluation, was mainly influenced by regular reviews of the learning process and was least affected by the use of different learning strategies. Self-confidence was primarily influenced by the ability to self-criticism in the context of enhanced learning, while accountability for learning-related decisions had the least impact.

Indeed, self-directed learning is a process where the responsibility for learning shifts from an external source to the individual. This process highly values the learner's individual control, allowing them to regulate their learning through self-control and responsibility, thereby enhancing their motivation. Numerous studies in the literature have found that self-directed learning can strengthen individuals' self-confidence, encourage autonomy and increase intrinsic motivation (Cronin-Golomb and Bauer, 2023; O'Shea, 2003). Additionally, this learning approach can positively contribute to the development of lifelong learning skills (Tekkol and Demirel, 2018). Our research results align with existing literature, revealing that students displayed a high level of self-directed learning skills, an outcome we found satisfying. These students, who pursued their education during the pandemic and formed our study group, appeared ready for innovative technologies, demonstrated motivation and self-control and showed an eagerness to learn. The fact that nursing students possessed a high level of self-directed learning skills and their views towards virtual reality technologies were positive, suggests that the use of innovative technologies such as gamification, virtual simulation and virtual reality in the education process could enhance both

student success and overall educational quality. This supports that implementing these technologies, which attract students' interest, in the classroom may lead to beneficial outcomes — our research findings could serve a catalyst for expending the use of innovative technologies in nursing education. This highlights the significance of evolving nursing curriculum to incorporate these innovative technologies.

6. Conclusion

This study indicated that nursing students have positive views towards virtual reality technologies. Specifically, students expressed a preference for the use of three-dimensional images in their classes, believing that they believe such technologies could help concretize learning topics and facilitate the learning process for the new generations. In terms of self-directed learning skills, the students were found to exhibit a high level of these abilities. Interestingly, our findings highlighted that gender influenced self-directed learning skills among students, but the academic year of study did not have an impact through traditional statistical techniques. Using a tree-based machine learning approach enabled us to identify nuanced distinctions that might not have been immediately apparent through traditional statistical analysis. This methodology offered an effective means for developing customized motivational strategies to address the unique needs of a diverse student demographic. The identification of the most and least influential subdimensions in the self-directed learning skills provides valuable insights for the future development of customized learning strategies, thereby enhancing these critical skills.

In light of the findings obtained from this research, we suggest the following:

- Develop and integrate virtual reality technology applications into nursing practice and assimilate them into the educational programs for nurses,
- Evaluate the effectiveness of virtual reality technology educational programs and integrate them to the nursing curriculum,
- Test the research findings with different study sample groups and countries,
- Develop a valid and reliable measurement tool for evaluating virtual reality technology,
- Incorporate courses related to self-directed learning methods, machine learning and virtual reality applications into nursing curriculum programs,
- Conduct qualitative in-depth interviews with nursing students.

Implementing these suggestions has the potential to restructure nursing education, fostering a more engaging, effective and technologically-forward learning environment for future healthcare professionals.

Ethical considerations

Ethical approval was obtained from the ethics committee of a university (Decision no. 2022/77, Dated: April 12, 2022).

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CRediT authorship contribution statement

Goktas Polat: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Kucukkaya Aycan:** Data curation, Formal analysis, Methodology, Resources, Validation, Visualization, Writing – original draft. **Turhan Zehra:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft. **Bodur Gonul:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.nepr.2024.103881.

References

Adib-Hajbaghery, M., Sharifi, N., 2017. Effect of simulation training on the development of nurses and nursing students' critical thinking: a systematic literature review. Nurse Educ. Today 50, 17–24. https://doi.org/10.1016/j.nedt.2016.12.011.

Artsın, M., Koçdar, S., Bozkurt, A., 2020. Examination of self-regulated learning skills of learners in the context of massive open online courses. Anadolu J. Educ. Sci. Int. 10 (1), 1–30. https://doi.org/10.18039/ajesi.681905.

Aydın, F., Şahin, Ç., 2021. Class teacher candidates' views on the use of virtual reality in education. Gaziantep Univ. J. Educ. Sci. 5 (2), 124–139. Retrieved from. ⟨https://dergipark.org.tr/tr/pub/guebd/issue/67489/1018956⟩.

Baykan, Z., Poyrazoğlu, S., Akşehirli Seyfeli, M.Y., 2023. Evaluation of erciyes university medical faculty students for self-learning and online learning. Tıp Eğitimi Dünyası 22 (67), 29–43. https://doi.org/10.25282/ted.1262576.

Bayram, Ş.B., Çalışkan, N., 2021. An innovative approach in psychomotor skill teaching for nurses: virtual reality applications. J. Educ. Res. Nurs. 18 (3), 356–362. https://doi.org/10.5152/jern.2021.81542.

Bodur, G., Kaya, H., 2017. Nurses looking future: 2050's. Ege Üniversitesi Hemşirelik Fakültesi Derg. 33 (1), 27–38. Retrieved from. ⟨https://dergipark.org.tr/tr/pub/egehemsire/issue/49327/630070⟩.

Bodur, G., Gumus, S., Gursoy, N.G., 2019. Perceptions of Turkish health professional students toward the effects of the internet of things (IOT) technology in the future. Nurse Educ. Today 79, 98–104. https://doi.org/10.1016/j.nedt.2019.05.007.

Breiman, L., 2001. Random forests. Mach. Learn. 45, 5–32.

Chan, Y.H., 2003. Biostatistics 102: Quantitative data–parametric & non-parametric tests. Singap. Med. J. 44 (8), 391–396. PMID: 14700417.

Cronin-Golomb, L.M., Bauer, P.J., 2023. Self-motivated and directed learning across the lifespan. Acta Psychol. 232, 103816 https://doi.org/10.1016/j.actpsy.2022.103816.

Dutucu, N., Özdilek, R., Acar, B.H., 2022. The effect of virtual reality on pain and anxiety during mammography: A randomized controlled study. Anatol. J. Health Res. 1 (3), 1–7. https://doi.org/10.29228/anatoljhr.53937.

Gedik, R., 2020. Students' views on the use of virtual reality technology in climate topic in middle school social studies course. J. Innov. Res. Soc. Stud. 3 (1), 33–53. Retrieved from. ⟨https://dergipark.org.tr/en/pub/jirss/issue/55333/706972⟩.

Goktas, P., Kucukkaya, A., Karacay, P., 2023. Leveraging the efficiency and transparency of artificial intelligence-driven visual Chatbot through smart prompt learning concept. Ski. Res. Technol. 29 (11), e13417 https://doi.org/10.1111/srt.13417.

Hasgören, S., Güvercin, S.G., 2023. Reflection of self-directed learning skills on affective experiences during the pandemic period. J. Educ. Life 37 (1), 183–202. https://doi.org/10.33308/26674874.2023371466.

Hernandez-de-Menendez, M., Escobar Díaz, C.A., Morales-Menendez, R., 2020. Educational experiences with Generation Z. Int. J. Interact. Des. Manuf. 14, 847–859. https://doi.org/10.1007/s12008-020-00674-9.

Hwang, G., Chang, C., Ogata, H., 2022. The effectiveness of the virtual patient-based social learning approach in undergraduate nursing education: A quasi-experimental study. Nurse Educ. Today 108, 105164. https://doi.org/10.1016/j.nedt.2021.105164.

Jallad, S.T., Işık, B., 2022. The effectiveness of virtual reality simulation as learning strategy in the acquisition of medical skills in nursing education: a systematic review. Ir. J. Med. Sci. 191 (3), 1407–1426. https://doi.org/10.1007/s11845-021-02695-z.

Jeong, S.Y.S., Lee, K.O., 2019. The emergence of virtual reality simulation and its implications for nursing profession. Korean J. Women Health Nurs. 25 (2), 125–128. https://doi.org/10.4069/kjwhn.2019.25.2.125.

Joung, J., Kang, K.I., 2022. Can virtual simulation replace clinical practical training for psychiatric nursing? Issues Ment. Health Nurs. 43 (8), 706–711. https://doi.org/10.1080/01612840.2022.2055684.
Karagülle, S., Berkant, H.G., 2022. Examining self-managed learning skills and thinking styles of university students. Gazi Üniversitesi Gazi Eğitim Fakültesi Derg. 42 (1), 669–710. https://doi.org/10.17152/gefad.1005908.
Kaya, M., Karaman, Ö.Z., 2022. Due to burn patients treated innovative technology: Virtual reality. Arch. Med. Rev. J. 31 (1), 46–51. https://doi.org/10.17827/aktd.992689.
Kılınç, H.N., Uzun, Y., 2022. Developing augmented reality application for neurosurgery. Eur. J. Sci. Technol. 33, 290–296. https://doi.org/10.31590/ejosat.1049487.
Kim, M.J., Kang, H.S., De Gagne, J.C., 2021. Nursing students' perceptions and experiences of using virtual simulation during the COVID-19 pandemic. Clin. Simul. Nurs. 60, 11–17. https://doi.org/10.1016/j.ecns.2021.06.010.
Kuleto, V., P.M.I., Stanescu, M., Ranković, M., Šević, N.P., Păun, D., Teodorescu, S., 2021. Extended reality in higher education, a responsible innovation approach for Generation Y and Generation Z. Sustainability 13 (21), 11814. https://doi.org/10.3390/su132111814.
McLeod, S., 2017. Kolb's learning styles and experiential learning cycle. Simply Psychol. 5.
Morin, K.H., 2020. Nursing education after COVID-19: Same or different? J. Clin. Nurs. 29 (17-18), 3117–3119. https://doi.org/10.1111/jocn.15322.
Noordien, I., Hoffman, J., Julie, H., 2020. Male students' motivations to choose nursing as a career. Afr. J. Health Prof. Educ. 12 (4), 220–223. https://doi.org/10.7196/AJHPE.2020.v12i4.1371.
O'Shea, E.A., 2003. Self-directed learning in nurse education: a review of the literature. J. Adv. Nurs. 43, 42–70. https://doi.org/10.1046/j.1365-2648.2003.02673.x.
Park, J.M., Seo, H.J., Kim, S.M., Kang, H., Lee, S.J., 2023. Association between COVID-19-related stress and self-directed learning ability among Korean nursing students. Nurse Educ. Pract. 69, 103613 https://doi.org/10.1016/j.nepr.2023.103613.
Plotzky, C., Lindwedel, U., Sorber, M., Loessl, B., König, P., Kunze, C., Kugler, C., Meng, M., 2021. Virtual reality simulations in nurse education: A systematic mapping review. Nurse Educ. Today 101, 104868. https://doi.org/10.1016/j.nedt.2021.104868.
Rajacich, D., Kane, D., Williston, C., Cameron, S., 2013. If they do call you a nurse, it is always a "male nurse": Experiences of men in the nursing profession. Nurs. Forum 48 (1), 71–80. https://doi.org/10.1111/nuf.12008.
Recepoğlu, S., 2021. Investigation of the relationship between social studies teacher candidates' lifelong learning tendencies and self-directed learning skills. Gazi Üniversitesi Gazi Eğitim Fakültesi Derg. 41 (1), 551–569. Retrieved from. ⟨https://dergipark.org.tr/tr/pub/gefad/issue/62024/867117⟩.
Rim, D., Shin, H., 2022. Development and assessment of a multi-user virtual environment nursing simulation program: A mixed methods research study. Clin. Simul. Nurs. 62, 31–41. https://doi.org/10.1016/j.ecns.2021.10.004.
Saab, M.M., Landers, M., Murphy, D., O'Mahony, B., Cooke, E., O'Driscoll, M., Hegarty, J., 2021. Nursing students' views of using virtual reality in healthcare: a qualitative study. J. Clin. Nurs. 31, 1228–1242. https://doi.org/10.1111/jocn.15978.
Salamonson, Y., Maneze, D., Smith, B.W., Duff, J., Theobald, K.A., Montayre, J., McTier, L., Donnelly, F., 2023. Are men treated differently in clinical placements during nursing studies? A cross-sectional study. J. Clin. Nurs. 32, 6354–6365. https://doi.org/10.1111/jocn.16760.
Sarıkoç, G., 2016. Use of virtual reality in the education of health care workers. Hemşirelikte Eğitim ve Araştırma 13 (1), 11–15. https://doi.org/10.5222/HEAD.2016.243.
Sarman, A., Sarman, E., Tuncay, S., 2021. Investigation of the quantity and content of postgraduate theses conducted using virtual reality in nursing and published in YOK Thesis in Turkey. Bingöl Üniversitesi Sağlık Derg. 2 (2), 71–82. Retrieved from. ⟨https://dergipark.org.tr/en/pub/bingolsaglik/issue/67782/1000436⟩.
Sarmasoğlu, Ş., Görgülü, S., 2015. Self-directed learning readiness levels of nursing students. Hacettepe Üniversitesi Hemşirelik Fakültesi Dergisi 1 (3), 13–25. Retrieved from. ⟨https://dergipark.org.tr/en/pub/hunhemsire/issue/7857/103392⟩.
Sümen, A., Evgin, D., 2022. Self-regulated learning levels of nursing students and their views on distance education. Adıyaman Üniversitesi Sağlık Bilim Derg. 8 (1), 45–56. https://doi.org/10.30569/adiyamansaglik.967965.
Şahin, K.G., Başak, T., 2022. Classification of simulation methods using in nursing education. Dokuz Eylül Üniversitesi Hemşirelik Fakültesi Elektronik Derg. 15 (1), 78–85. https://doi.org/10.46483/deuhfed.947218.
Şen, S., Usta, E., Bozdemir, H., 2022. The effect of mobile virtual reality on operating room nursing education. Teach. Learn. Nurs. 17, 199–202. https://doi.org/10.1016/j.teln.2022.01.008.
Şenyuva, E., 2019. Reflections on nursing education of technological developments. FNJN Florence Nightingale J. Nurs. 27 (1), 79–90. https://doi.org/10.26650/FNJN322556.
Teke A. The investigation of the self-directed learning experiences of adult individuals: A narrative research. Electronic Theses and Dissertations. 2020. Necmettin Erbakan Üniversitesi, Konya, Turkey.
Tekkol, A.İ., Demirel, M., 2018. An investigation of self-directed learning skills of undergraduate students. Front. Psychol. 9, 2324 https://doi.org/10.3389/fpsyg.2018.02324.
Tepe, T., Kaleci, D., Tuzun, H., 2016. Eğitim teknolojilerinde yeni eğilimler: Sanal gerçeklik uygulamaları. 10th Int. Comput. Instr. Technol. Symp. . (ICITS) 16 (18), 547–555.
Tuna, A., Özkan, D., 2022. A new reality in learning for nursing students: Virtual reality. J. Int. Educ. Sci. 9 (32), 320–331. https://doi.org/10.29228/INESJOURNAL.64133.
Ulupınar, F., Toygar, Ş.A., 2020. Use Technol. Nurs. Educ. Sample Pract. Fiscaoeconomia 4 (2), 524–537. https://doi.org/10.25295/fsecon.2020.02.013.
Yılmazsoy, B., Kahraman, M., 2019. Review of self-directed learning skills of distance education students. J. Theor. Educ. Sci. 12 (2), 783–818. https://doi.org/10.30831/akukeg.429362.
Yu, M., Yang, M.R., 2022. Effectiveness and utility of virtual reality infection control simulation for children with COVID-19: Quasi-experimental study. JMIR Serious Games 10 (2), e36707. https://doi.org/10.2196/36707.
Zeng, Y., Zeng, L., Cheng, A.S., Wei, X., Wang, B., Jiang, J., Zhou, J., 2022. The use of immersive virtual reality for cancer-related cognitive impairment assessment and rehabilitation: A clinical feasibility study. Asia-Pac. J. Oncol. Nurs. 9 (12), 100079 https://doi.org/10.1016/j.apjon.2022.100079.