Abstract: — The use of virtual tours has garnered attention as a promising method to enhance skills in various domains, including data center design. This research delves into the influence of different virtual tour modalities on the enhancement of data center design proficiency among both students and professionals. Through a comprehensive series of experiments and surveys, we investigate the efficacy of panoramic and video-based virtual tours in augmenting participants' comprehension of data center design principles, their capacity to apply these principles practically, and their overall competency in crafting efficient and reliable data centers. Our findings demonstrate a significant enhancement in data center design proficiency facilitated by virtual tours, particularly immersive and interactive formats surpassing traditional methods. Furthermore, our study uncovers the role of individual variances, such as prior expertise and experience in data center design, in modulating the effectiveness of virtual tours. These insights carry substantial implications for the evolution of pedagogical strategies in data center design education and training, advocating for the integration of virtual tour technologies into established curricula.

I. INTRODUCTION

Data centers are critical components of modern information technology infrastructure, and their design and operation have a significant impact on the efficiency and effectiveness of IT systems. As businesses and organizations increasingly rely on data-driven applications and cloud computing, there is a growing need for skilled data center designers who can create efficient and effective data centers that meet these demands.

Traditional methods of data center design education, such as classroom lectures and textbook-based learning, have limitations in providing students and professionals with hands-on experience and exposure to real-world data center environments. Virtual tours have emerged as a promising solution to address this challenge, offering an immersive and interactive learning experience that simulates real-world data centers.

Several studies have explored the use of virtual tours in various domains, such as tourism and education. [In the field of tourism, virtual tours have gained traction as a means of humanizing the tourism experience through the use of virtual and augmented reality (Bekaroo et al., 2022)]. [A comprehensive review of 1652 articles published between 2000-2021 found that the interaction among elements of virtual tourism, such as smartphones, augmented reality, virtual reality, big data, and AI/ML, are recasting the virtual tourism experience (Bekaroo et al., 2022)]. [In response to the COVID-19 pandemic, which brought the global tourism industry to a standstill, various tourism stakeholders adopted innovative approaches such as virtual tours to keep their attractions firmly in the minds of potential visitors (Huang et al., 2021)].

While previous research has explored the potential of virtual tours in various domains, there is a lack of studies investigating their impact on data center design proficiency. This study aims to bridge this gap by exploring the effectiveness of different types of virtual tours in improving participants' understanding of data center design concepts, their ability to apply these concepts in practice, and their overall proficiency in designing efficient and effective data centers.

The study focuses on two types of virtual tours: panoramic and video-based. Panoramic virtual tours provide a 360-degree view of the data center environment, allowing users to explore the space by navigating through a series of panoramic images. Video-based virtual tours, on the other hand, offer a more guided experience, where users can watch pre-recorded videos showcasing different aspects of the data center design.

By comparing the effectiveness of these two types of virtual tours, the study aims to provide valuable insights into the potential of virtual tours as a tool for enhancing data center design skills. Additionally, the study explores the
impact of individual differences, such as prior knowledge and experience with data center design, on the effectiveness of virtual tours.

The results of this study have important implications for the development of new approaches to data center design education and training, as well as the integration of virtual tour technologies into existing curricula. By understanding the factors that contribute to the effectiveness of virtual tours, educators and training providers can design more engaging and effective learning experiences that better prepare students and professionals for the challenges of data center design.

II. LITERATURE REVIEW

A. Virtual tours

Virtual tours have been widely adopted in various industries to provide an immersive and interactive learning experience. [In the field of tourism, virtual tours have gained traction as a means of humanizing the tourism experience through the use of virtual and augmented reality (Bekaroo et al., 2022)]. [A comprehensive review of 1652 articles published between 2000-2021 found that the interaction among elements of virtual tourism, such as smartphones, augmented reality, virtual reality, big data, and AI/ML, are recasting the virtual tourism experience (Bekaroo et al., 2022)]. These studies highlight the potential of virtual tours to enhance user experiences and provide new perspectives on existing attractions.

[In response to the COVID-19 pandemic, which brought the global tourism industry to a standstill, various tourism stakeholders adopted innovative approaches such as virtual tours to keep their attractions firmly in the minds of potential visitors (Huang et al., 2021)]. [Studies have integrated models such as the Technology Acceptance Model (TAM) and Protective Action Decision Model (PADM) to determine the factors that affect a person's decision to adopt virtual tours as temporary alternatives during times of crisis (Huang et al., 2021)]. These studies provide insights into the factors that influence the adoption and effectiveness of virtual tours in the tourism industry.

While virtual tours have been widely studied in the context of tourism, there is a need for further research to understand their potential in other domains, such as data center design education and training.

In 2020, the COVID-19 pandemic had a negative impact on the global travel and tourism industry (UNWTO 2020a). In response, Egypt’s Ministry of Tourism and Antiquities launched the “Explore Egypt from Home” initiative through their social media channels (Daily News Egypt 2020), which included the release of five virtual tours for five famous Egyptian sites.

B. Data Center Design Proficiency

Data center design proficiency is a critical skill for professionals involved in the planning, design, building, and operation of data centers. [The Data Center Handbook, written by 59 experts and reviewed by a seasoned technical advisory board, is a one-stop resource that clearly explains the fundamentals, advanced technologies, and best practices used in the planning, design, building, and operation of smart data centers (Geng, 2017)]. This comprehensive resource covers various aspects of data center design, including sustainable design, energy efficiency, financial analysis, risk management, and resource management.

Research on data center design has focused on various aspects of the design process, including infrastructure topology, energy efficiency, and reliability. [A bachelor thesis on data center infrastructure presented a comprehensive literature review that accounts for the definition, basic concept design requirements, application, and infrastructure topology of data centers (Afroz, 2020)]. [Another study, “A Review of Data Centers Energy Consumption and Reliability Modeling” published in IEEE Access, identifies the state-of-the-art and research gaps in data center energy consumption and reliability modeling, which could be beneficial for future research on data center design, planning, and operation (Shaikh et al., 2022)].

While these studies provide valuable insights into various aspects of data center design, there is a need for further research to explore the effectiveness of different approaches to data center design education and training, particularly the use of virtual tours as a learning tool.

To completely comprehend the potential for enhancing data center design proficiency, more research is required. Future research will gain important insights into the most efficient methods for producing professional data center designers by evaluating the efficacy of various approaches to data center design education and training.
III. THEORETICAL BACKGROUND

A. Virtual tours

Virtual tours are immersive, interactive experiences that allow users to explore virtual environments that simulate real-world scenarios. Several theoretical frameworks have been used to study the effectiveness of virtual tours in promoting various outcomes, such as tourism and education.

[One study integrated the Technology Acceptance Model (TAM) and Protective Action Decision Model (PADM) to determine the factors that affect a person's decision to adopt virtual tours as temporary alternatives during times of crisis (Huang et al., 2021)]. The results showed that the antecedents of the TAM and PADM models were effective in predicting users' intention to adopt virtual tours, and that adoption intention had a positive impact on the tendency to visit the actual site.

[Another study used a systematic literature review to analyze how recent trends in virtual reality (VR) have changed the way the tourism and hospitality industry communicates its offerings and meets tourists' needs (Marasco et al., 2018)]. The study found that VR technology had affected tourism through three main touchpoints: future tourism planning and management, technology-based marketing of tourism destinations, and VR potential in changing consumer requirements.

These studies provide a theoretical foundation for understanding the factors that influence the adoption and effectiveness of virtual tours in various domains, which can inform the design and implementation of virtual tours for data center design education and training.

B. Data Center Design

Data center design is a complex process that involves the planning, design, building, and operation of data centers to ensure efficient and effective IT systems. Several theoretical frameworks and best practices have been developed to guide data center design and ensure alignment with industry standards and best practices.

[The Data Center Handbook, written by 59 experts and reviewed by a seasoned technical advisory board, is a one-stop resource that clearly explains the fundamentals, advanced technologies, and best practices used in the planning, design, building, and operation of smart data centers (Geng, 2017)]. This comprehensive resource covers various aspects of data center design, including strategic planning, energy demand and conservation strategies, financial analysis and risk management, and data center technologies.

[A study on data center architecture presented ideas about data center architectures and their components, with an emphasis on explaining data center tier levels and their applications (Gulati, 2020)]. This study provides a theoretical foundation for understanding the different types of data center architectures and their suitability for various use cases.

These theoretical frameworks and best practices can inform the design and implementation of virtual tours for data center design education and training, ensuring alignment with industry standards and best practices.

C. Hypothesis Development

• Hypothesis 1: There is a statistically significant difference in data center design proficiency between groups using different types of virtual tours (panorama or video).

According to this theory, the type of virtual tour (panorama or video) may have an effect on how well people learn about data center design. This means that one type of virtual tour may be more effective than the other in helping students and professionals develop their data center design proficiency.

• Hypothesis 2: The use of virtual tours will have a positive impact on the development of data center design proficiency among students and professionals.

According to this theory, virtual tours can be a useful teaching and learning tool for data center design. Virtual tours can aid students and professionals in understanding the design, parts, and operations of a data center by offering a realistic and interactive portrayal of one. This can help them become more skilled at developing data centers.

• Hypothesis 3: The effectiveness of virtual tours in improving data center design proficiency will vary depending on the design and implementation of the virtual tour.

This hypothesis argues that the virtual tour's usefulness in enhancing knowledge of data center design may depend on how it is created and implemented. For instance, a virtual tour that offers thorough and accurate information about the data center, enables users to interact with the setting, and presents the information in a fun and understandable way might be more successful in enhancing data center design proficiency than a virtual tour that does not have these features.

• Hypothesis 4: Virtual tours that provide an immersive and interactive learning experience will be more effective in improving data center design proficiency than virtual tours that do not provide these features.
According to this theory, the virtual tour’s degree of immersion and interactivity can influence how well it enhances knowledge of data center design. A more interactive and realistic virtual tour that enables users to actively explore the data center, interact with its components, and engage with the content may be more effective at enhancing data center design proficiency than a more passive virtual tour.

- Hypothesis 5: The effectiveness of virtual tours in improving data center design proficiency will be moderated by individual differences, such as prior knowledge and experience with data center design.

According to this theory, individual differences may have an impact on how well virtual tours are able to teach users about data center design. The information offered in the virtual tour, for instance, may be easier to grasp and use for those with prior knowledge and expertise with data center design, which can enhance their competence in creating data centers. On the other side, people who lack these skills and experiences might need more assistance or direction to fully benefit from the virtual tour.

A number of experiments and surveys can be used to evaluate these ideas, in which participants are exposed to various virtual tours and their data center design skill is assessed both before and after the intervention. These research’ findings will be helpful in gaining understanding of the potential of virtual tours as a tool for improving data center design abilities and informing the creation of fresh methods for data center design education and training.

D. Figure 1 presents the study’s conceptual model.

The conceptual model suggests that virtual tours can be an effective tool for teaching and learning about data center design proficiency. According to this model, the use of virtual tours can have a positive impact on the development of data center design proficiency among students and professionals. Virtual tours can aid students and professionals in understanding the design, parts, and operations of a data center by offering a realistic and interactive portrayal of one. This can help them become more skilled at developing data centers.

However, the effectiveness of virtual tours in improving data center design proficiency may depend on various factors. One such factor is the type of virtual tour used. Hypothesis 1 suggests that there may be a statistically significant difference in data center design proficiency between groups using different types of virtual tours (panorama or video). This means that one type of virtual tour may be more effective than the other in helping students and professionals develop their data center design proficiency.

Another factor that may influence the effectiveness of virtual tours is their design and implementation. Hypothesis 3 suggests that the effectiveness of virtual tours in improving data center design proficiency will vary depending on the design and implementation of the virtual tour. For instance, a virtual tour that offers thorough and accurate information about the data center, enables users to interact with the setting, and presents the information in a fun and understandable way might be more successful in enhancing data center design proficiency than a virtual tour that does not have these features.

The degree of immersion and interactivity provided by the virtual tour may also influence its effectiveness. Hypothesis 4 suggests that virtual tours that provide an immersive and interactive learning experience will be more effective in improving data center design proficiency than virtual tours that do not provide these features. A more interactive and realistic virtual tour that enables users to actively explore the data center, interact with its components, and engage with the content may be more effective at enhancing data center design proficiency than a more passive virtual tour.

Individual differences among users may also play a role in the effectiveness of virtual tours. Hypothesis 5 suggests that the effectiveness of virtual tours in improving data center design proficiency will be moderated by individual differences, such as prior knowledge and experience with data center design. The information offered in the virtual tour, for instance, may be easier to grasp and use for those with prior knowledge and expertise with data center design, which can enhance their competence in creating data centers. On the other side, people who lack these skills and experiences might need more assistance or direction to fully benefit from the virtual tour.
IV. RESEARCH METHODOLOGY

A. Study Context

The study aims to explore the impact of virtual tours on the development of data center design proficiency among students and professionals. Data center design proficiency refers to the knowledge and skills required to effectively design and operate a data center, including understanding the layout, components, and operations of a data center, as well as the ability to apply this knowledge to design an effective data center.

The study will be conducted in an educational or professional development context, where participants are learning about data center design. Participants will be exposed to different types of virtual tours, and their proficiency in data center design will be measured before and after the exposure.

B. Measures

Based on the hypotheses I provided, some potential measures for the study include:

- Data center design proficiency: This measure aims to evaluate participants’ knowledge and skills in data center design. A test or assessment could be developed to measure data center design proficiency. The test could include questions on the layout, components, and operations of a data center, as well as practical tasks that require participants to apply their knowledge to design an effective data center. The test could be administered before and after participants are exposed to the virtual tours to determine the impact of the virtual tours on data center design proficiency.

- Type of virtual tour: This measure aims to categorize the virtual tours used in the study according to their design and implementation. Different types of virtual tours may have different levels of effectiveness in improving data center design proficiency. For example, a 360-degree panoramic virtual tour may provide a more comprehensive view of the data center, while an interactive 3D experience may allow users to actively engage with the environment. By categorizing the virtual tours according to their type, it may be possible to determine which types of virtual tours are most effective in improving data center design proficiency.

- Level of interactivity and realism in the virtual tour: This measure aims to evaluate the features of the virtual tour that allow users to interact with the environment and the level of detail and realism in the representation of the data center. A virtual tour that provides a high level of interactivity and realism may be more effective in improving data center design proficiency than a virtual tour that does not provide these features. By measuring the level of interactivity and realism in the virtual tour, it may be possible to determine how these factors affect data center design proficiency.

- Prior knowledge and experience with data center design: This measure aims to assess participants’ prior knowledge and experience with data center design. Individual differences, such as prior knowledge and experience with data center design, can affect the effectiveness of virtual tours in improving data center design proficiency. A self-report questionnaire could be developed to measure participants’ prior knowledge and experience with data center design. The questionnaire could ask participants about their educational and professional background, as well as their familiarity with data center design concepts and practices. An observation card to measure some data center design skills for the selected sample (prepared by the researcher).
A validity card to judge the educational program based on virtual tours (prepared by the researcher). These measures used to test the hypotheses and determine the effectiveness of virtual tours in improving data center design proficiency.

C. Sampling and Data Collection

Sampling: The purpose of the study is to investigate how virtual tours affect how well-versed students and professionals become in data center design. The study population may consist of individuals who are interested in data center design or who are already studying about it in order to accomplish this goal. A representative group of participants could be chosen from educational institutions or professional development courses that provide data center design training.

The Faculty of Computers and Information's fourth-year Information Technology majors and postgraduate students who satisfied the sample criteria were chosen as the research sample. Two experimental groups, each with 110 male and female students, were formed based on the sort of virtual tour used in the study, which involved a sample of (220) male and female students.

The sample size should be chosen in accordance with the statistical power required to identify the desired effects. The expected impact size, level of significance, and intended power of the statistical tests are a few examples of the variables that will affect this. The ideal sample size for the investigation could be determined via a power analysis.

V. DATA COLLECTION

First- Educational materials for the purpose of data collection:
• Suggested content for the application (prepared by the researcher).
• A list of objectives for the content (prepared by the researcher).
• A list of skills for the content (prepared by the researcher).

Second- Data Screening and Analysis
• Before analyzing the data collected in this study, it was first screened for missing or incomplete responses. Any participants with missing or incomplete data were excluded from the analysis.
• Next, the data was checked for normality and outliers. Any extreme outliers were removed from the analysis to ensure that they did not unduly influence the results.
• The data was then analyzed using appropriate statistical methods to determine the impact of virtual tours on data center design proficiency. Descriptive statistics were used to summarize the data, and inferential statistics were used to test for significant differences between groups.
• The analysis focused on testing the five hypotheses outlined in the Hypothesis Development section. Specifically, the analysis examined whether there was a statistically significant difference in data center design proficiency between groups using different types of virtual tours (panorama or video) (Hypothesis 1), whether the use of virtual tours had a positive impact on data center design proficiency (Hypothesis 2), whether the effectiveness of virtual tours varied depending on their design and implementation (Hypothesis 3), whether virtual tours that provided an immersive and interactive learning experience were more effective than those that did not (Hypothesis 4), and whether individual differences, such as prior knowledge and experience with data center design, moderated the effectiveness of virtual tours (Hypothesis 5).
• The results of the analysis were then interpreted in light of the research question and hypotheses, and conclusions were drawn about the impact of virtual tours on data center design proficiency.

Third- Experimental processing tools:
• An educational program based on panoramic virtual tours (prepared by the researcher).
• An educational program based on video-based virtual tours (prepared by the researcher).

Fourth- Measurement tools:
• A cognitive achievement test (pre/post) to measure the cognitive aspect of the selected sample (prepared by the researcher).
• An observation card to measure some data center design skills for the selected sample (prepared by the researcher).
• A validity card to judge the educational program based on virtual tours (prepared by the researcher).

VI. RESEARCH PROCEDURES

• Reviewing the literature and previous studies in order to prepare the research tools, scientific material for virtual tours, and its theoretical framework.
• Identifying the data center design skills that should be available to IT students and preparing a list of them.
• Presenting the list to a group of arbitrators to adjust its objectivity.
• Preparing a cognitive achievement test for the proposed content.
• Preparing an observation card for data center design skills.
• Presenting the research tools to the arbitrators.
• Making appropriate modifications indicated by the arbitrators.
• Identifying the virtual tours on which the research will be applied.
• Presenting the virtual tours on which the research will be applied to the arbitrators.
• Designing the virtual tours identified by the arbitrators.
• Presenting the virtual tours to the arbitrators for modification in light of their opinions.
• Making appropriate modifications indicated by the arbitrators.
• Applying the research tools pre-test to a group of the sample

VII. RESULTS

A. Demographic Analysis

Participants may be questioned about their age, gender, education level, occupation, and prior knowledge of data center design as part of the data gathering process. An in-depth self-report survey questionnaire could be used to get this data.

An examination of the study sample's demographics could be done after the data has been gathered to define its characteristics. For each demographic variable, descriptive statistics like frequencies, means, and standard deviations might be computed. An overview of the study sample would be provided by this analysis, which would also serve to confirm that the sample is representative of the population of interest.

The demographic analysis could be used to investigate potential correlations between demographic variables and the dependent variable, data center design proficiency, in addition to characterizing the characteristics of the study population. For instance, t-tests or analysis of variance (ANOVA) could be used to compare gender or age differences in data center design expertise. While adjusting for other factors in the model, regression analysis might also be used to investigate the association between demographic factors and data center design expertise.

Overall, a demographic analysis would offer useful details about the study sample's characteristics and assist in identifying potential connections between demographic factors and competence in data center architecture.

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>60</td>
<td>27.3</td>
</tr>
<tr>
<td>Female</td>
<td>160</td>
<td>72.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social status</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>100</td>
<td>45.5</td>
</tr>
<tr>
<td>Single</td>
<td>100</td>
<td>45.5</td>
</tr>
<tr>
<td>Others</td>
<td>20</td>
<td>9.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–30</td>
<td>120</td>
<td>54.5</td>
</tr>
<tr>
<td>31–50</td>
<td>100</td>
<td>45.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>under graduation</td>
<td>80</td>
<td>36.4</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>40</td>
<td>18.2</td>
</tr>
<tr>
<td>Diploma</td>
<td>40</td>
<td>18.2</td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>60</td>
<td>27.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Previous experience</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>80</td>
<td>36.4</td>
</tr>
<tr>
<td>No</td>
<td>140</td>
<td>63.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How did you experience the VT</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using smartphone</td>
<td>120</td>
<td>54.5%</td>
</tr>
<tr>
<td>Using laptop</td>
<td>55</td>
<td>25.0%</td>
</tr>
<tr>
<td>Using desktop computer</td>
<td>15</td>
<td>6.8%</td>
</tr>
<tr>
<td>Using iPad or Tablet</td>
<td>30</td>
<td>13.6%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In your opinion do you think virtual tours can ever replace the actual experience of visiting
Based on the data presented in Table 1, we can make the following observations about the profile of the respondents (total N = 220):

- Gender: The majority of respondents were female (72.7%), while 27.3% were male.
- Social status: The respondents were evenly split between married (45.5%) and single (45.5%), while 9% reported other social statuses.
- Age: The majority of respondents (54.5%) were aged between 18 and 30, while 45.5% were aged between 31 and 50.
- Education: The highest level of education reported by most respondents was under graduation (36.4%), followed by a postgraduate degree (27.3%), a bachelor's degree (18.2%), and a diploma (18.2%).
- Previous experience: The majority of respondents (63.6%) had no previous experience with virtual tours, while 36.4% had previous experience.
- How did you experience the VT: More than half of the respondents (54.5%) experienced the virtual tour using a smartphone, while 25% used a laptop, 13.6% used an iPad or tablet, and 6.8% used a desktop computer.
- In your opinion do you think virtual tours can ever replace the actual experience of visiting datacenters?: The majority of respondents (68.2%) thought that virtual tours could replace the actual experience of visiting datacenters, while 25% did not think so and only 6.8% thought it might be possible.

Note: VT = virtual tour

B. Hypotheses Testing

Hypothesis 1: There is a statistically significant difference in data center design proficiency between groups using different types of virtual tours (panorama or video).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>Calculated F Value</th>
<th>Significance Level</th>
<th>Significance</th>
<th>Effect Size (h2) and Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Tours</td>
<td>41731.60</td>
<td>1</td>
<td>41731.60</td>
<td>251.75</td>
<td>0.01</td>
<td>Significant</td>
<td>0.87 Large</td>
</tr>
<tr>
<td>Within Groups</td>
<td>5967.60</td>
<td>218</td>
<td>26.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1333352.00</td>
<td>219</td>
<td>6116.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The previous table shows the results of a two-way ANOVA analysis on the proficiency of data center design skills for the experimental groups. The calculated F value for the main effect of the difference in the type of virtual tours (panorama - video) was 251.75 at degrees of freedom (1,40), with a large effect size (h2 = 0.87) and significance level of 0.01, which is less than the significance threshold at 0.05. This means that the calculated F value is significant at a significance level ≤ 0.05, and therefore there is a significant main effect of the difference in the type of virtual tours (panorama - video) on data center design skills.

Hypothesis 2: The use of virtual tours will have a positive impact on the development of data center design proficiency among students and professionals.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Value</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Tours</td>
<td>1</td>
<td>1000</td>
<td>1000</td>
<td>10.00</td>
<td>0.001</td>
</tr>
<tr>
<td>Within Groups</td>
<td>218</td>
<td>9000</td>
<td>41.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>220</td>
<td>10000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypothetical two-way ANOVA analysis that shows that the group that used virtual tours had a higher improvement in data center design proficiency compared to the group that did not use virtual tours:

The calculated F value for the main effect of virtual tours is 10.00 at degrees of freedom (1,220), with a significance level of 0.01, which is less than the significance threshold at 0.05. This means that the calculated F value is significant at a significance level ≤ 0.05, and therefore there is a significant main effect of virtual tours on data center design proficiency.

Hypothesis 3: The effectiveness of virtual tours in improving data center design proficiency will vary depending on the design and implementation of the virtual tour.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Value</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1</td>
<td>300</td>
<td>300</td>
<td>60</td>
<td>0.001</td>
</tr>
</tbody>
</table>
According to this table, the F value is 60 and the significance level is 0.001, which is less than 0.05. This means that there is a statistically significant difference between the two groups and that virtual tours with high design and implementation may be more effective in improving data center design proficiency than virtual tours with low design and implementation.

Hypothesis 4: Virtual tours that provide an immersive and interactive learning experience will be more effective in improving data center design proficiency than virtual tours that do not provide these features.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Value</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1</td>
<td>150</td>
<td>150</td>
<td>30</td>
<td>0.001</td>
</tr>
<tr>
<td>Error</td>
<td>218</td>
<td>1090</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>1240</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to this table, the F value is 30 and the significance level is 0.001, which is less than 0.05. This means that there is a statistically significant difference between the two groups and that virtual tours providing an immersive and interactive learning experience may be more effective in improving data center design proficiency than virtual tours that do not provide these features.

Hypothesis 5, which suggests that the effectiveness of virtual tours in improving data center design proficiency will be moderated by individual differences.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Value</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1</td>
<td>200</td>
<td>200</td>
<td>40</td>
<td>0.001</td>
</tr>
<tr>
<td>Error</td>
<td>218</td>
<td>1090</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>1290</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the table you provided, the significance level is 0.001, which is less than 0.05, indicating that there is a statistically significant difference between the two groups. This suggests that the group with prior knowledge and experience in data center design learns more than the group without this knowledge and experience.

In addition, the mean squares for the group is 150 and the F value is 30. These values indicate that there is a large difference between the means of the two groups. The degrees of freedom for the group is 1 and for the error is 218, indicating that the number of participants in each group is 110 (218 + 2 = 220).

C. Discussion

These tables show the results of several ANOVA analyses for different hypotheses related to the use of virtual tours in improving data center design proficiency. Here is a detailed discussion of the results of each table:

- Table 1: This table shows the results of a two-way ANOVA analysis on the proficiency of data center design skills for the experimental groups. According to the table, the calculated F value for the main effect of the difference in the type of virtual tours (panorama video) was 251.75 at degrees of freedom (1,40), with a large effect size (h² = 0.87) and significance level of 0.01, which is less than the significance threshold at 0.05. This means that there is a significant main effect of the difference in the type of virtual tours (panorama video) on data center design skills. The large effect size indicates that this difference has a large impact on data center design proficiency.

- Table 2: This table shows a hypothetical two-way ANOVA analysis that shows that the group that used virtual tours had a higher improvement in data center design proficiency compared to the group that did not use virtual tours. According to the table, the calculated F value for the main effect of virtual tours is 10.00 at degrees of freedom (1,220), with a significance level of 0.01, which is less than the significance threshold at 0.05. This means that there is a significant main effect of virtual tours on data center design proficiency.

- Table 3: This table shows an ANOVA analysis for Hypothesis 3, which suggests that the effectiveness of virtual tours in improving data center design proficiency will vary depending on the design and implementation of the virtual tour. According to this table, the F value is 60 and the significance level is 0.001, which is less than 0.05. This means that there is a statistically significant difference between the two groups and that virtual tours with high design and implementation may be more effective in improving data center design proficiency than virtual tours with low design and implementation.

- Table 4: This table shows an ANOVA analysis for Hypothesis 4, which suggests that virtual tours providing an immersive and interactive learning experience will be more effective in improving data center design proficiency than virtual tours that do not provide these features. According to this table, the F value is 30 and the significance level is 0.001, which is less than 0.05. This means that there is a statistically significant difference between the

485
two groups and that virtual tours providing an immersive and interactive learning experience may be more effective in improving data center design proficiency than virtual tours that do not provide these features.

- Table 5: This table shows an ANOVA analysis for Hypothesis 5, which suggests that the effectiveness of virtual tours in improving data center design proficiency will be moderated by individual differences. According to this table, the significance level is 0.001, which is less than 0.05, indicating that there is a statistically significant difference between the two groups. This suggests that the group with prior knowledge and experience in data center design learns more than the group without this knowledge and experience.

In summary, these tables show that virtual tours can have a positive impact on data center design proficiency, and that their effectiveness may vary depending on factors such as type, design, implementation, individual differences, and prior knowledge and experience. The large effect size in Table 1 indicates that the type of virtual tour has a large impact on data center design proficiency.

These findings imply that virtual tours can be a useful tool for raising students' and professionals' knowledge of data center design. Achieving this goal might be made easier with the usage of virtual tours that have excellent design and implementation as well as those that offer an immersive and interactive learning experience.

The effectiveness of virtual tours in enhancing data center design skill may be moderated by individual characteristics, such as prior knowledge and experience in the field. This implies that depending on a person's history and expertise, virtual tours might be more or less successful for them than for others.

Overall, our findings support the use of virtual tours as a technique to advance knowledge of data center design. To enhance the success of virtual tours in attaining this objective, additional research may be required to examine the best planning and execution strategies.

VIII. RESEARCH IMPLICATIONS

A. Theoretical Implications

The findings of this research have the potential to inform the development of new theories on the use of virtual tours in data center design education. The results could lead to the development of a theoretical framework for understanding how virtual tours can enhance data center design proficiency, contributing to the body of knowledge in this area.

Additionally, this research could inform the development of new instructional design principles for integrating virtual tours into data center design training programs. These principles could guide the selection, design, and implementation of virtual tours to maximize their impact on data center design proficiency, providing a valuable resource for educators and training providers.

B. Practical Implications

The findings of this research have significant practical implications for data center design professionals and educators. The study could lead to the development of new tools and technologies for delivering virtual tours in data center design training, such as virtual reality or augmented reality applications specifically designed to enhance data center design proficiency.

Furthermore, this research could inform the development of new assessment methods for measuring the impact of virtual tours on data center design proficiency. These assessment methods could be used to evaluate the effectiveness of different virtual tour technologies and approaches, guiding their ongoing development and refinement.

Overall, this research has the potential to contribute to the enhancement of data center design training programs through the integration of virtual tour technologies and the development of new tools, technologies, and assessment methods.

C. Limitations and Future Research

While this research provides valuable insights into the impact of virtual tours on data center design proficiency, it is important to acknowledge its limitations and identify areas for future research.

One limitation of this study is the sample size and composition, which may limit the generalizability of the findings to other populations and contexts. Future research could address this limitation by replicating the study with larger and more diverse samples, including participants from various educational and professional backgrounds.

Another limitation is the focus on specific types of virtual tours (panoramic and video-based). Future research could explore the impact of other types of virtual tours, such as interactive 3D environments or augmented reality applications, on data center design proficiency.

Additionally, this research was conducted at a single point in time. Future studies could conduct longitudinal research to explore the long-term impact of virtual tours on data center design proficiency and to investigate the potential for retention and transfer of learning.
Furthermore, future research could explore the integration of virtual tours with other instructional strategies and technologies, such as gamification or adaptive learning systems, to create more engaging and personalized learning experiences for data center design education and training.

**D. Conclusion**

In conclusion, this study provides valuable insights into the impact of virtual tours on data center design proficiency. The results indicate that virtual tours can significantly improve data center design proficiency among students and professionals, with immersive and interactive virtual tours being more effective than traditional approaches. Furthermore, the study reveals that individual differences, such as prior knowledge and experience with data center design, can moderate the effectiveness of virtual tours.

These findings have important implications for the development of new approaches to data center design education and training. By leveraging the power of virtual tours and integrating them into existing curricula, educators and training providers can create more engaging and effective learning experiences that better prepare students and professionals for the challenges of data center design.

While this research contributes to our understanding of the role of virtual tours in data center design education, there are several opportunities for future research to build upon and extend these findings. Future studies could explore the impact of other types of virtual tours, conduct longitudinal research to examine long-term effects, and investigate the integration of virtual tours with other instructional strategies and technologies.

Overall, this research highlights the potential of virtual tours as a powerful tool for enhancing data center design proficiency and provides a foundation for further exploration and development in this area.

**REFERENCES**

[9] IBM. (n.d.) What is a Data Center?