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Exploring the Impact of Inclusive Digital Elements in the Design of 3D Simulation-based Educational Games

Daniell DiFrancesca, Pennsylvania State University, Behrend College

Dr. Daniell DiFrancesca earned her Ph.D. in educational psychology from North Carolina State University in 2015. She is currently an Assistant Professor of Educational Psychology at Penn State Behrend. Dr. DiFrancesca's research interests focus on developing self-regulation in learning with a focus on designing and evaluating classroom-based interventions. Additionally, Dr. DiFrancesca has worked as an evaluator for university programs and community initiatives.

Christian Enmanuel Lopez, Lafayette College

I am an Assistant Professor of Computer Science with an affiliation in Mechanical Engineering at Lafayette College.

I completed my Ph.D. from the Harold and Inge Marcus Department of Industrial and Manufacturing Engineering at the Pennsylvania State Un

Dr. Omar Ashour, Pennsylvania State University, Behrend College

Dr. Omar Ashour is Associate Director for Research and a Professor of Industrial Engineering at Pennsylvania State University, The Behrend College. Dr. Ashour received the B.S. degree in Industrial Engineering/Manufacturing Engineering and the M.S. degree in Industrial Engineering from Jordan University of Science and Technology (JUST) in 2005 and 2007, respectively. He received his M.Eng. degree in Industrial Engineering/Human Factors and Ergonomics and a Ph.D. degree in Industrial Engineering and Operations Research from The Pennsylvania State University (PSU) in 2010 and 2012, respectively. Dr. Ashour was the inaugural recipient of William and Wendy Korb Early Career Professorship in Industrial Engineering in 2016. Dr. Ashour's research areas include data-driven decision-making, modeling and simulation, data analytics, immersive technologies, and process improvement. He contributed to research directed to improve design and engineering education.

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Abstract

This work explores the integration of inclusive digital elements in the design phase of educational games, specifically within a manufacturing simulation developed to teach operations management concepts. While educational games have become a valuable tool in engineering education, there is limited research on how inclusive design considerations can impact game design, user engagement, and learning potential. This research focuses on understanding how inclusive design elements (i.e., accessible design elements and inclusive character representations, including multilingual signages, diverse workers, diverse flags for different countries, disability-accessible paths, and inclusive restrooms) influence the player's perceived value of the game, even before educational content is introduced. The experiment includes walking through two game environments: one that incorporates inclusive design elements (intervention) and another that does not (control). User feedback is collected through a survey to assess the impact of these elements, including user-perceived learning from these environments, and the game's authenticity in simulating real-world workplace environments.

The work in this paper addresses how inclusive design elements affect user perceptions of the game's inclusivity, the importance of such elements for enhancing engagement and learning outcomes, and potential barriers to implementing inclusive design in educational games. By analyzing user responses, this study contributes to a deeper understanding of how inclusive design considerations should be embedded into the design of educational tools for industrial engineering. The results provide insights for educators and game developers on how to incorporate these elements into 3D simulation-based learning environments to promote inclusivity and foster more equitable learning experiences. The findings also offer broader implications for integrating inclusive digital elements into engineering education, specifically in the design and development of educational games.

1 Introduction

Educational games have emerged as an effective means to enhance engagement and learning in engineering education. Games can bridge the gap between theoretical knowledge and real-world application, offering students an interactive and immersive platform to explore complex concepts. Despite the growing trend in their adoption, the research on the integration of inclusive design principles in educational game development remains limited. This gap is particularly critical given the systemic inequities within STEM fields, which continue to underserve minority groups [1], [2], [3].

Inclusive design in educational games encompasses a range of principles, from ensuring accessibility for learners with disabilities to creating culturally representative and diverse narratives. Research studies underscore the positive impact of inclusive digital elements, such as character customization, inclusive narratives, and accessible game mechanics, in fostering engagement and learning outcomes among diverse demographics [1], [3]. For example, Harteveld et al. demonstrate that embedding equity-driven design in game-based learning not only improves learning outcomes but also creates equitable experiences for all students [1].

Challenges persist in the integration of inclusive practices in educational games, particularly within 3D simulation environments, despite the promising findings mentioned above. These challenges include the lack of empirical research on the need and impact of inclusive design during the early stages of game development, as well as the broader cultural and structural barriers that limit representation in game-based learning [1], [4]. Theoretical developments in gaming research post-COVID-19 pandemic have emphasized the importance of integrating diverse perspectives, yet practical applications often fall short of these ideals [1], [5].

The work in this paper explores the role of inclusive digital elements (i.e., accessible design elements and inclusive character representations, including multilingual signages, diverse workers, diverse flags for different countries, disability-accessible paths, and inclusive restroom) in the early design stage of a manufacturing simulation game aimed to teach operations management concepts. The work will evaluate student feedback across environments with and without inclusive digital features. The results of the work provide actionable insights into the importance and the potential impact of inclusive digital elements in reshaping educational games. Through a focus on early-stage design considerations, this work contributes to broader efforts to create equitable and engaging learning tools in STEM education.

2 Literature Review

The engineering field has continued to struggle with low numbers of female and minority individuals in the profession, which was traditionally composed of white males. In general, STEMM (Science, Technology, Mathematics, and Medicine) careers account for almost 25% of the U.S. workforce [6]. STEMM careers can generate higher earnings than other fields and provide job security [7]. Increasing underrepresented groups in the engineering program needs to start early, targeting these students at the undergraduate level. Undergraduate programs have struggled with student retention, particularly of female and minority students. In 2016, data showed that only 25% of engineering bachelor's degrees in the United States were earned by underrepresented minorities [8]. Another study in 2019 indicated that only 20% of engineering degrees were earned by women [9], not accounting for the intersectionality of those individuals who are both women and of minority races. What happens in undergraduate engineering programs that either prevents underrepresented groups from pursuing this program or causes those who do pursue engineering degrees to quit?

One potential issue is that engineering students from underrepresented groups report experiencing negative interactions with peers and faculty. Approximately two-thirds of minority engineering students have experienced discrimination in their programs [10]. These everyday occurrences can accumulate over time, adversely affecting the psychological and emotional well-being of those targeted [11]. Discrimination negatively impacts persistence and performance [12], sometimes being cited as the reason underrepresented students leave their programs [13].

Discrimination can have real impacts on student outcomes and become a barrier to student success. Undergraduates who have experienced discrimination tend to have lower academic performance [11]. Reduced academic performance could lead to further isolation in the STEM fields for underrepresented groups that are already struggling to belong. In a study of minority undergraduate engineering students, True-Funk et al. found that those who experienced discrimination reported reduced self-esteem, isolation, and stereotype threat [14]. This study found these results to be more pronounced in Latinx students, potentially due to the increased negative political rhetoric involving undocumented immigrants. Even graduate-level African American males report experiencing negative race-based interactions with fellow students and faculty in their programs [15].

Minority students in STEM programs face discrimination from peers, faculty, and advisors, which makes them question their ability to be successful in the program [16]. Female science students continue to encounter a hostile environment in STEM courses, leading to alienation, isolation, and a loss of confidence [17]. In addition to the sexual discrimination female students experience, African American male students experience racial discrimination [18]. Instances of both sexual and racial discrimination are often ignored by professors and administrators in STEM programs [17], [18], contributing to the attrition of underrepresented groups in STEM fields [19], [20].

Because underrepresented groups in STEM experience discrimination from multiple levels and these experiences force many to abandon STEM fields, it is important to consider how educational games can be used to improve their experiences. In fact, a survey of digital gamers found that players noticed the lack of diversity in game characters and individuals across all races wanted to see an increase in diversity in games [21]. The addition of these elements also serves to normalize the presence of underrepresented groups to the majority of students who engage in discriminatory behaviors. Research examining diversity exposure shows a decrease in race essentialism over time [22] and this exposure in a simulation could serve the same purpose. Creating an equitable environment that is welcoming for all students is an important step to increase underrepresented students participation in engineering programs. Exploring the presence of culturally relevant design elements in games is the first step in improving the experiences of underrepresented individuals. The development of this computer-based learning simulation is an opportunity to include elements that support diversity in the field and create a positive environment. The current exploratory study tests student perceptions of the inclusive digital elements in a 3D simulation-based education game and measures students' reactions to these elements in the design stage before educational content is introduced in the classroom. The researchers tested students' perceptions of two game environments that were identical except for the addition of inclusive digital elements in one environment. While several studies have examined the impact of diverse students being able to create diverse avatars to better represent themselves [23]. This does not address the attitudes of students who are engaging in discriminatory behaviors. The current study gauges all students' perceptions of the presence of diverse game elements because the game needs to address not just the underrepresented groups, but also the majority groups who are creating a hostile environment. The results of this exploratory study will inform the simulation development in hopes of promoting greater diversity and acceptance in the engineering field.

3 Methodology

3.1 3D Simulation-based Learning Environment

The 3D simulation-based learning environments utilized in this work were created using Unity, a robust and versatile cross-platform game engine by Unity Technologies [24]. Unity enables the creation of immersive three-dimensional (3D) and two-dimensional (2D) games and simulations, making it a popular choice for educational tools in engineering and other fields [24].

The simulated environments depict a water bottle manufacturing system designed to emulate real-world production processes. These environments are intended to evolve into game-based learning modules that can serve as virtual substitutes for in-person visits to manufacturing facilities. The system includes several stations, each representing a critical phase in the manufacturing process:

- **Blow molding machine**: Produces plastic water bottles.
- **Cleaning station**: Prepares bottles for the filling stage.
- **Filling station**: Fills bottles with water.
- **Capping and sealing station**: Secures the bottles.
- **Labeling station**: Applies branding and product details.
- **Wrapping and packaging**: Wraps sets of bottles into a package based on the customer's order.

Other components, such as conveyor belts and robotic arms, facilitate cooling and material transfer between stations. Figure 1 provides a snapshot of one of the simulated environments.

Figure 1. A screenshot from the water bottle manufacturing environment

The future learning objectives for these environments will aim to prepare students for roles in production operations and supply chain management. These objectives may include but are not limited to: Collecting and analyzing data to improve system performance measures, estimating raw material requirements to meet customer demand, evaluating process flow, and recommending optimization solutions.

However, this study focuses on the design phase of these environments, specifically investigating the influence of inclusive digital design elements on user perceptions. By evaluating the usability, engagement, and perceived value of the game before introducing educational content, this research seeks to establish the importance of inclusivity in simulation-based learning tools.

Videos of two versions of the manufacturing environment were developed for this experiment:

1. **Inclusive environment**: Features accessible design elements and inclusive character representations, including multilingual signages, diverse workers, diverse flags for different countries, disability-accessible paths, and inclusive restrooms.
2. **Non-Inclusive environment**: Lacks these inclusive features.

Participants were introduced to these environments through two videos hosted on YouTube:

- **Environment 1 (Intervention)**: https://rb.gy/q3tb08
- **Environment 2 (Control)**: https://rb.gy/80dkvh

Snapshots of these environments, as shown to participants, are included in the Appendix. By examining user feedback through the survey shown in the Appendix, this work investigates the role of inclusive design elements in fostering engagement, perceived fairness, and authenticity in simulated workplace environments.

3.2 Experimental Design

The team recruited students from various majors, including engineering and non-engineering. After consenting to participate in the study, participants began the survey (see Appendix). The survey was conducted using Qualtrics [25]. The survey included the following data collection points.

Demographics. Participants completed demographic questions including age, race, gender, major, and academic standing.

Prior Work Experience. Participants were asked to report their prior work experience.

Perception of Learning using Educational Games. The survey included four questions requesting the students to rate their perception of using video games and online simulations for learning. Responses were recorded on a five-point Likert scale.

Video Simulations. Participants watched two videos for the inclusive and non-inclusive simulation environments. The first video was a walkthrough of the factory floor with no inclusive digital elements (control video). The second video was a walkthrough of the factory floor with inclusive digital elements (intervention video). Each video lasted 2 minutes and 37 seconds. The inclusive digital elements include racially diverse workers, signs in multiple languages, and inclusive restrooms. Students were asked to select their preferred working environment. Students were then prompted to explain why they selected that environment in an open-ended response item. After the open-ended question, the rest of the survey was administered, consisting of the questions shown in the Appendix. It should be noted that the subjects were not informed about the differences between the environments.

Perception of Inclusive Elements Impact on Learning. Participants completed a five-item questionnaire on their perception of the impact of inclusive digital elements on their learning. Responses were recorded on a five-point Likert scale.

Importance of Inclusive Digital Elements. Participants completed a five-item questionnaire on the importance of diverse elements in the workplace. Responses were recorded on a five-point Likert scale.

Capability of Diverse Individuals in the Workplace. Participants completed a four-item question on their perception of the capability of diverse individuals in the workplace on a five-point Likert scale.

Future Work with Diverse Individuals. Participants completed a four-item question on their perception of working with diverse individuals in the future on a five-point Likert scale.

3.3 Participants

Participants were recruited from five different courses at Penn State Behrend. A total of 52 participants took part in the study. However, after filtering for participants who completed all questions, had a completion time of at least 6 minutes (as the videos' length is around 5 minutes), and excluding outliers based on completion time identified using a Tukey's test [26]. The final dataset included responses from 41 participants.

On average, participants took 11.76 minutes to complete the survey (Median: 10.85, Min: 6.35, Max: 23.47, SD: 4.15). Of the 41 participants, 21 identified as female (51.22%) and 20 as male (48.78%). The average age of participants was 20.78 years (Median: 20, Min: 18, Max: 28, SD: 2.13). Most participants identified as "White" (90.24%), with smaller proportions identifying as Asian (7.32%), and Hispanic (2.44%).

A total of 56.1% (23 participants) were enrolled in engineering-related majors (e.g., Industrial Engineering, Mechanical Engineering, Plastics Engineering Technology), while 43.9% (18 participants) were from non-engineering majors (e.g., Psychology, Early Childhood Education, History). Regarding academic standing, six participants were freshmen, 10 were sophomores, 12 were juniors, and 13 were seniors. Additionally, 24 participants reported having prior work experience, with an average of 27.21 months of work experience (Median: 12, Min: 3, Max: 98, SD: 28.16).

4 Results and Discussion

Experience with computer simulation models and video games

Participants' experiences with computer simulation models and video games were analyzed to understand their familiarity with these domains. Regarding computer simulation models (i.e., responses to the question: *How do you describe your experience with computer simulation models?*), the majority of participants (63.41%) reported having "*Some Experience*," while 34.15% indicated having "*None,*" and only 2.44% identified as "*Expert.*" A Chi-Square Goodness-of-Fit test showed that the observed distribution significantly differed from a uniform distribution ($\chi^2 = 22.878$, df = 2, $p < 0.001$). This result suggests that participants' levels of experience with computer simulation models are unevenly distributed, with a clear dominance of some level of experience.

In terms of video game experience (i.e., responses to the question: *How do you describe your experience with video games*?), 53.66% of participants reported "*Some Experience*," 29.27% identified as "*Expert*," and 17.07% indicated having "*None*." Similarly, a Chi-Square Goodness-of-Fit test showed a significant deviation from a uniform distribution ($\chi^2 = 22.878$, df = 2, $p < 0.001$). These results suggest that participants' experiences with video games are also unevenly distributed, with a substantial proportion of participants reporting some level of experience. Overall, the findings indicate that while most participants have some level of familiarity with both computer simulation models and video games, their expertise levels are notably higher in video games, with a greater proportion identifying as "*Expert*" in this domain.

This distribution demonstrates a higher familiarity with video games compared to computer simulation models, particularly among those identifying as "*Expert*." Although a statistical test was not explicitly conducted for this distribution, the proportions highlight a notable difference in participants' expertise levels between the two domains.

Learning with simulations and games

Participants' agreement with statements related to learning from online simulations and games was analyzed using a five-point Likert scale. The responses were treated as rank-ordered data, and the distributions were assessed using descriptive statistics and Wilcoxon signed-rank tests to compare responses against a neutral midpoint of three. Table 1 shows the proportion of responses for the different equations.

Table 1. Proportion of responses

Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can learn from online simulations (%)	0	0	29.27	58.54	12.2
I can learn from online games (%)	0	2.44	26.83	53.66	17.07
I enjoy learning from online simulations (%)	0	7.32	34.15	41.46	17.07
I enjoy learning from online games (%)	0	14.63	21.95	41.46	21.95

For the statement *"I can learn from online simulations"*, the majority of participants agreed (58.54%). The median response was four (i.e., “agreed”), and the Wilcoxon test indicated that responses were significantly higher than the neutral point ($V = 435$, $p < 0.001$). These results suggest a strong positive perception of the learning potential of online simulations. In response to the statement *"I can learn from online games"*, the majority of participants also agreed (53.66%).

The median response was four (i.e., “agreed”), with a significant deviation from neutrality ($V = 453$, $p < 0.001$), indicating that participants generally believe online games can support learning.

The statement *"I enjoy learning from online simulations"* showed slightly less agreement, with just 41.46% agreeing. The median response was four, and the Wilcoxon test confirmed a significant positive shift from the neutral point ($V = 346.5$, $p < 0.001$). This suggests that participants generally find online simulations enjoyable for learning, though with slightly more variation in agreement levels. Lastly, regarding the statement *"I enjoy learning from online games"*, 41.46% agreed. The median response was four, with a significant deviation from neutrality ($V = 456$, $p < 0.001$). These results indicate that participants generally enjoy learning from online games, with a broader range of responses compared to online simulations.

Overall, participants expressed positive perceptions of both online simulations and games as tools for learning, with slightly higher agreement for their learning potential than for their enjoyment. These findings highlight the potential of both mediums as engaging educational tools for the participant.

Work environment preference

Participants were asked to observe two videos of work environments (See Section 3 and Appendix) and subsequently, indicate their preferred work environment. Among the responses, 56.1% of participants ($n = 23$) preferred *Environment 1* (intervention), while 43.9% ($n = 18$) preferred *Environment 2* (control). A Chi-Square Goodness-of-Fit test was conducted to determine whether the observed distribution significantly deviated from an expected uniform distribution. The test result ($\chi^2 = 0.610$, $df = 1$, $p = 0.435$) indicated that the observed preferences did not significantly differ from what would be expected by chance. These findings suggest that participants, on average, showed no strong overall preference between the two work environments, with the proportions being relatively close to equal.

When examining participants' preferences for work environments in relation to their academic major (engineering vs. non-engineering), distinct patterns emerged. Among non-engineering majors, the majority preferred the intervention environment (16 participants, 88%) over the control environment (2 participants, 11%). In contrast, engineering majors showed a strong preference for the control environment (16 participants, 69.6%) compared to the intervention environment (7 participants, 30.4%). A Chi-squared test of independence was conducted to assess whether the preference for work environment was significantly associated with participants’ majors. The results indicated a significant association ($\chi^2 = 11.736$, $df = 1$, $p = 0.0006$), suggesting that the choice of work environment was strongly influenced by whether participants were from engineering or non-engineering fields.

Additionally, the gender distribution across academic majors revealed that non-engineering majors were predominantly female (15 females vs. 3 males), while engineering majors were predominantly male (17 males vs. 6 females). However, when analyzing work environment preferences based on gender, the relationship appeared less pronounced. Female participants primarily preferred the intervention environment (17 participants, 81%) compared to the control environment (4 participants, 19%), while male participants showed a preference for the control environment (14 participants, 70%) over the intervention environment (6 participants, 30%). A Chi-Square test showed a significant association between gender and work environment preference ($\chi^2 = 8.829$, df = 1, p = 0.003). While significant, this association was less pronounced than the relationship observed with academic majors, and when using a Bonferroni-corrected alpha value of 0.001 (due to the multiple statistical tests performed), these results are not as statistically significant as the ones above.

These findings suggest that academic background has a stronger influence on work environment preferences than gender. However, the demographic distribution, with non-engineering majors being predominantly female and engineering majors predominantly male, highlights the complex interplay between these factors.

Inclusive digital elements in learning simulations and the workplace

Participants were asked to evaluate their agreement with statements regarding inclusive digital elements in learning simulations and perceptions of workplace diversity, as well as the importance of diversity in hiring practices (see Appendix). Table 2 shows a summary of these responses. Across the questions, the responses revealed a general trend of strong agreement, with most participants rating these elements positively.

In the context of learning simulations, most participants indicated that the inclusion of inclusive digital elements positively influenced their learning. Statements such as *"Including diverse characters in learning simulations improves my learning"* and *"Including characters with different genders improves my learning"* garnered the highest levels of agreement, with median responses of four (i.e., "agree") and average ratings of 3.46 and 3.44, respectively. Wilcoxon tests showed significant deviations from the neutral midpoint of three for these two responses, further underscoring participants' positive perceptions of diversity in learning environments. However, when using a Bonferroni-corrected alpha value of 0.001, these results are not statistically significant.

Similarly, the findings reveal a strong consensus among participants regarding the capability of diverse individuals to work in a factory setting. Statements addressing individuals of different races and genders both received the highest average score of 4.76, with minimal variation (SD = 0.49), indicating broad agreement. Similarly, the statement regarding individuals who speak a variety of languages had an average score of 4.68 (SD = 0.61), reflecting strong support. While slightly lower, the statement about individuals with disabilities received an average score of 4.37 (SD = 0.70), still indicating a high level of agreement. All results were statistically significant ($p < 0.001$), highlighting participants' strong positive perceptions of inclusivity in the workplace.

Similarly, the findings indicate a strong belief among participants that their future careers will involve working with diverse groups of individuals. The statements about working with racially diverse individuals and individuals with different genders both received high average scores of 4.63 and 4.61, respectively, with median responses of 5. Similarly, the statement regarding individuals with disabilities garnered an average score of 4.37 (SD = 0.89), while the statement about working with non-English speaking individuals had a slightly lower average score of 4.22

Table 2. Summary of responses to DEI-related questions

No	Questions	Min	Max	Median	Avg.	Sd.	p-value
1	The inclusion of diversity, equity, and inclusivity elements in learning simulations improves my learning	1	5	3	3.24	1.18	0.266
2	Including diverse characters in learning, simulations improves my learning	1	5	4	3.46	0.98	0.007
3	Including characters with disabilities in learning simulations improves my learning	1	5	3	3.32	0.96	0.050
4	Including characters of different genders in learning simulations improves my learning	1	5	4	3.44	1.03	0.017
5	Including non-English speaking characters in learning simulations improves my learning	1	5	4	3.29	1.08	0.125
6	Individuals of different races are capable of working in the factory	3	5	5	4.76	0.49	<0.001
7	Individuals of different genders are capable of working in the factory	3	5	5	4.76	0.49	<0.001
8	Individuals who speak a variety of languages are capable of working in the factory	2	5	5	4.68	0.61	<0.001
9	Individuals with disabilities are capable of working in the factory	2	5	4	4.37	0.70	<0.001
10	In my future career, I will be working with racially diverse individuals	2	5	5	4.63	0.66	<0.001
11	In my future career, I will be working with individuals of different genders	3	5	5	4.61	0.59	<0.001
12	In my future career, I will be working with individuals with disabilities	1	5	5	4.37	0.89	<0.001
13	In my future career, I will be working with non-English-speaking individuals	1	5	4	4.22	1.01	<0.001
14	How important are issues of diversity, equity, and inclusivity	1	5	4	3.93	1.15	<0.001
15	How important is it to hire employees of different races	1	5	4	3.85	1.11	<0.001
16	How important is it to hire employees with disabilities	1	5	4	3.68	1.06	0.001
17	How important is it to hire employees of different genders	1	5	4	3.88	1.23	<0.001
18	How important is it to hire employees who speak different languages	1	5	4	3.73	1.10	0.001

(SD = 1.01). All results were statistically significant ($p < 0.001$), underscoring participants' strong expectations of diversity in their professional environments.

When asked about the importance of diversity in hiring practices, participants consistently rated these aspects as highly important. The statement regarding the importance of DEI issues received an average score of 3.93 with a median response of 4. Similarly, the importance of hiring employees of different races and genders was rated highly. Hiring employees with disabilities and those who speak different languages was slightly lower but still positively rated. All results were statistically significant ($p \leq 0.001$), indicating strong support for the importance of diverse hiring practices among participants.

For questions in Table 2, further analysis compared responses based on participants' preferred work environments (control vs. intervention). Participants who preferred the intervention environment consistently reported higher levels of agreement with statements about the inclusion of diverse characters in learning simulations (i.e., questions 1-5 in Table 2), with average ratings near 3.70–3.87, compared to those preferring the control environment, whose average ratings were around 2.61–3.06. For questions 6-9, the average ratings for participants who preferred the intervention environment were 4.48-4.78 vs 4.22-4.72, for questions 10-13, the average ratings were 4.52-4.78 vs 3.83-4.44, and for questions 14-18, the average ratings were 3.91-4.26 vs 3.50-3.67. However, based on a Wilcoxon signed-rank test, these differences were not statistically significant at a Bonferroni corrected alpha value of 0.001.

Overall, the findings indicate a strong positive perception of DEI in both educational and workplace contexts. While participants across groups generally rated diversity as important, those favoring the intervention environment exhibited consistently higher agreement and stronger appreciation for the value of diversity in simulations and professional practices. These results suggest the importance of tailoring educational and workplace interventions to account for individual preferences and contexts.

Open-ended Question Analysis

Participant responses to the item, *Why do you prefer that environment? Were there any specific features you preferred?"*, were organized into two groups based on which Environment the students selected. The responses were read through two times, and common ideas were identified. The ideas were reviewed and placed into themes. The responses were then reread and coded for the identified themes. Exemplars were identified.

The responses of participants who preferred the intervention environment were coded for five common themes. As shown in Table 3, more than half of these participants mentioned specific environmental features they liked, such as flags, and signage with multiple ethnic holidays represented. Participants also noted the signs having multiple languages as positive, as well as the accessibility sign when exiting the building. About half of the students specifically used the term *inclusive* when describing the environment, while a portion of the respondents also believed that employees would feel welcome in the intervention environment. The distinction of seeing employees as people and not just laborers was explicitly made by two respondents as well. Individuals selecting the intervention environment noticed and appreciated the inclusive elements.

Responses of participants who preferred the control environment were coded for seven common themes in Table 3. Some participants in this group mentioned specific items that were present in the control environment, but as a reason, they did *not* select that environment. Instead, these participants felt that DEI elements were distracting and would lead to employee conflicts. Participants believed the factory environment should be professional and exclude personal ideologies. A few students even made anti-DEI comments, indicating the program should focus on American themes only and should not include any elements that reference sexual orientation, . In general, the overall sentiment seemed to be that this environment should focus on work only and any other features were detrimental to the facility.

In sum, the qualitative data helped identify which features participants noticed and their reactions to these features. Regardless of which environment was selected, a majority of participants noticed the added DEI elements. Whether individuals viewed these elements as negative or positive seems to be influenced by students' majors. Humanities and Social Sciences programs often include coursework that focuses on the importance of DEI, while Engineering majors may not have the same exposure. Future studies will need a larger, more diverse participant pool to understand how these elements are perceived by underrepresented groups and when content is introduced if there are any differences in learning outcomes.

Table 3. Qualitative analysis

Subjects who preferred the intervention environment		
	Frequency	%
Mention Specific Items	12	54.55%
Inclusive	10	45.45%
Employee Feelings, Being Welcome	8	36.36%
Unrelated Response	6	27.27%
See Employees as People, Not Just Laborers	2	9.09%
Subjects who preferred the control environment		
Anti-DEI	7	43.75%
Mention Specific Items in the Environment	6	37.50%
Personal Verses Professional Environment	5	31.25%
DEI Causes Conflicts	4	25.00%
Focus on Work	4	25.00%
Unrelated Reason	4	25.00%
DEI Elements Distract	2	12.50%

In addition, the responses to the open-ended question were analyzed to provide insights into participants' perceptions, sentiments, and key topics associated with their selections. Of the 23 participants who selected the intervention environment, 22 of them responded. The responses varied in length, ranging from 15 to 409 characters, with an average of approximately 142 characters. Sentiment analysis was performed using the VADER (Valence Aware Dictionary and Sentiment Reasoner) model [27], which assigns a compound sentiment score to each response, ranging from -1 (most negative) to +1 (most positive). The sentiment analysis for this group revealed a mean score of 0.459, indicating a generally positive tone. Sentiment scores ranged from neutral (0.0) to highly positive (0.885), with the most positive responses highlighting inclusivity and engaging elements, such as the intervention environment *"had more inclusive and engaging elements" (0.885)*. Neutral responses tended to focus on descriptive elements without emotional tone.

Furthermore, topic modeling was performed using Latent Dirichlet Allocation [28]. The number of topics was chosen based on the Coherence Score, which measures the interpretability of topics. The score was maximized for six topics, ensuring the most meaningful representation of the dataset. Topic modeling identified six key themes for this group. Topic 1 emphasized inclusivity and the overall feel of the space, with terms like "make," "space," and "inclusive." Topic 2 focused on positivity and accessibility, featuring words like "holidays," "general," and "sign." Topic 3 highlighted decorations and liveliness, with words such as "decoration," "liveliness," and "welcome." Topic 4 centered on physical characteristics like "flags," "room," and "wall," while Topic 5 emphasized diversity and discovery, including terms like "diversity," "workplace," and "new." Lastly, Topic 6 focused on spaciousness and organization, featuring words like "spacious," "organized," and "celebrations."

Of the 18 participants who selected the control environment, only 16 of them responded. Their responses showed greater variability in length, ranging from 12 to 1,014 characters, with an average length of approximately 214 characters. The sentiment analysis revealed a slightly less positive tone overall, with a mean sentiment score of 0.328. Sentiment scores ranged from negative (-0.296) to positive (0.794). Negative sentiment responses, such as *"No sexual banners on walls" (-0.296)* and *"I believe that* [the intervention environment] *can create a distraction" (-0.273)*, reflected a preference for neutrality and professionalism. Conversely, positive responses, such as *"Fewer flags and personal items would lead to less distraction" (0.794)*, highlighted the value of a focused, distraction-free workplace. Moreover, topic modeling identified seven distinct themes for this group. Topic 1 emphasized workplace functionality, with terms like "hours," "listed," and "machine." Topic 2 centered on personal experiences and feelings, featuring words like "like," "workplace," and "flags." Topic 3 highlighted inclusivity and neutrality, with terms like "flags," "respect," and "purpose." Topic 4 addressed visual elements and personal beliefs, such as "flag," "orientation," and "sexual." Topic 5 discussed physical elements, focusing on terms like "bathroom," "banners," and "professional." Topic 6 reflected on personal agendas and beliefs, including words like "necessary," "personal," and "imposed." Lastly, Topic 7 emphasized focus and productivity, with words like "focused," "relaxed," and "job."

Overall, the findings highlight distinct differences in participants' perceptions of the two environments. Responses for the intervention environment emphasized inclusivity, decorations, and a welcoming atmosphere, with a generally more positive tone. In contrast, responses for the control environment focused on professionalism, neutrality, and minimizing distractions, reflecting a preference for a structured and work-oriented environment. These insights illustrate contrasting values and priorities, with the intervention environment resonating more with inclusivity and engagement, and the control environment appealing to those prioritizing professionalism and focus.

5 Conclusions and Future Works

This paper investigates the role of inclusive digital elements in 3D simulation-based learning environments, focusing on their impact on user perceptions of inclusivity, engagement, and workplace authenticity. Two environments were presented: one that incorporated inclusive digital design elements (intervention) and another without these features (control). Participants were asked to evaluate these environments and indicate their preferences.

The results indicate notable differences in preferences based on demographic and academic backgrounds. Non-engineering majors and female participants showed a statistically significant preference for the inclusive environment, citing elements like representation and accessibility as critical for fostering a welcoming and equitable learning atmosphere. Conversely, engineering majors and male participants preferred the non-inclusive environment, often emphasizing professionalism and focus over inclusivity. Despite these differences, most participants expressed positive perceptions of diversity, equity, and inclusion (DEI) in both educational and workplace contexts.

The specific demographics of the participants (e.g., a majority of White) limit the generalizability of the results. In addition, the simulations presented to participants did not include educational content, which may have affected their perceptions of the environments. These limitations highlight the need for further investigation into the broader impacts of inclusivity in educational tools.

Future research should aim to explore incorporating educational content and evaluate how inclusive design elements impact learning outcomes when integrated with specific operations management content. Moreover, to improve the validity and relevance of findings, future studies should include participants from a wider range of demographic and academic backgrounds. This would help capture the perspectives of underrepresented groups and provide a more equitable view of inclusivity in educational environments. Furthermore, the researcher should develop methods for balancing inclusivity with professionalism, ensuring that educational tools appeal to a broad audience while maintaining their effectiveness as learning platforms.

This study provides a foundational understanding of the importance of inclusive digital elements in educational games and offers insights for educators and game developers. By addressing these areas, future research can contribute to the creation of more equitable and effective learning environments in engineering education.

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Appendix

Survey Questions

The survey starts with the consent form. If the subjects are 18 years old or older, and they consent to the study, they are asked demographic questions (age, gender, race, major, disability presence, spoken language other than English, work experience, experience with simulation and video games), and then they are asked the following questions.

Rate your agreement with the following statements on a scale of 1 to 5 (Strongly Disagree to Strongly Agree):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can learn from online simulations.	○	○	○	○	○
I can learn from online games.	○	○	○	○	○
I enjoy learning from online simulations.	○	○	○	○	○
I enjoy learning from online games.	○	○	○	○	○

Play the videos below for two digital workspace environments. Watch one video at a time. Once done, proceed to the next page.

This is **Environment 1**

This is **Environment 2**

Which work environment would you prefer to work in?

○ Environment 1

○ Environment 2

Why do you prefer that environment? Were there any specific features you preferred?

Which environmnet would you prefer?

○

○

Which environmnet would you prefer?

○

○

Which environmnet would you prefer?

○

○

Rate your level of agreement with the following statements on a scale of 1 to 5 (Strongly Disagree to Strongly Agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The inclusion of diversity, equity, and inclusivity elements in learning simulations improves my learning.	○	○	○	○	○
Including diverse characters in learning simulations improves my learning.	○	○	○	○	○
Including characters with disabilities in learning simulations improves my learning.	○	○	○	○	○
Including characters with different genders in learning simulations improves my learning.	○	○	○	○	○
Including non-english speaking characters in learning simulations improves my learning.	○	○	○	○	○

Rate how important you think each of the following is on a scale of 1 to 5 (Not at all Important to Extremely Important)

	Not at all Important	Not Important	Neutral	Important	Extremely Important
How important are issues of diversity, equity, and inclusivity?	○	○	○	○	○
How important is it to hire employees of different races?	○	○	○	○	○
How important is it to hire employees with disabilities?	○	○	○	○	○
How important is it to hire employees of different genders?	○	○	○	○	○
How important is it to hire employees who speak different languages?	○	○	○	○	○

Rate your level of agreement with the following statements on a scale of 1 to 5 (Strongly Disagree to Strongly Agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Individuals of different races are capable of working in the factory.	○	○	○	○	○
Individuals of different genders are capable of working in the factory.	○	○	○	○	○
Individuals who speak a variety of languages are capable of working in the factory.	○	○	○	○	○
Individuals with disabilities are capable of working in the factory.	○	○	○	○	○

Rate your level of agreement with the following statements on a scale of 1 to 5 (Strongly Disagree to strongly Agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
In my future career, I will be working with racially diverse individuals.	○	○	○	○	○
In my future career, I will be working with individuals with different genders.	○	○	○	○	○
In my future career, I will be working with individuals with disabilities.	○	○	○	○	○
In my future career, I will be working with non-english speaking individuals.	○	○	○	○	○