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Article

Bridging the Gap: Virtual Reality as a Tool for De-Escalation Training in Disability Support Settings

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Abstract: Managing complex behaviors in disability support settings requires competent de-escalation skills. However, the current training methods often lack sufficient opportunities for realistic practice. This study details a three-stage development and evaluation of a virtual reality (VR) application for disability support staff to safely build de-escalation skills through simulated interactions. The first phase involved creating VR prototype scenarios depicting escalations with adolescent clients. Next, 12 disability support experts conducted content validation by refining the scenarios to confirm appropriateness and realism. Finally, a pilot study tested the tool's usability and examined the initial construct validity in 20 participants. The prototype achieved high usability ratings (average 81.0 (SD 10.7) on the System Usability Scale). Additionally, a positive correlation between VR performance and empathy levels, as measured using the Toronto Empathy Questionnaire, was found (Pearson's r = 0.487, p = 0.035). The promising results highlight the VR application's potential as a transformative training tool. Future research should expand scenario diversity and compare VR with traditional methods to establish its efficacy in diverse settings and offer a path to enhance staff and student capabilities in challenging environments.

Keywords: disability support; virtual reality; training; de-escalation; empathy; validity; prototype

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1. Introduction

Disability support settings can present challenging situations, requiring staff to effectively manage the complex emotions and behaviors of their neurodivergent clients. In these situations, effective management goes beyond merely maintaining order; it involves upholding individuals' dignity and autonomy within a positive behavior support framework while also ensuring their safety and well-being [1]. To successfully navigate these complex dynamics, staff need a combination of theoretical knowledge and practical, real-world skills. Without adequate training in recognizing triggers, early signs of agitation, and employing de-escalation techniques, staff reactions may worsen frustration and aggression, thereby endangering their own safety and that of the clients [1,2]. De-escalation involves psychosocial techniques that span verbal and non-verbal communication that are aimed at calming tensions and reducing aggression [3,4]. These techniques are integral to handling situations involving individuals who exhibit disturbed or aggressive behavior [4].

The motivation for the current research stems from the critical need for effective de-escalation training to ensure the safety and well-being of both staff and clients while upholding individuals' dignity and autonomy. This need is particularly acute in disability support settings, where complex interactions between staff and neurodivergent clients can lead to challenging situations.

Frustration, both in clients and staff, often acts as a precursor to more overt forms of aggression. In an emotionally charged atmosphere, instances of frustration can rapidly escalate to physical or verbal aggression [5], posing challenges for both staff and client safety.

This issue is not unique to disability care but is prevalent in many human services and healthcare contexts, where managing complex emotions and behaviors from the individuals being supported is a daily reality [6,7].

When inadequately managed, these situations can lead to the use of restrictive practices, which can cause a loss of dignity, physical, and psychological harm to clients; induce trauma; and erode trust in support workers and/or caregivers [1,8,9]. Conversely, such aggressive encounters can profoundly affect the mental well-being of support workers, leading to emotional exhaustion and heightened stress levels [6,10,11].

The complex interplay between supporting essential needs, mitigating frustrations, and the risks of harm highlights the critical need for effective training in anticipating triggers, recognizing early signs of frustration, and employing de-escalation techniques [12]. Such training should empower staff to effectively address and mitigate the underlying frustrations, thereby preventing an escalation [13].

The current training methods for de-escalation in disability support and healthcare settings rely heavily on lectures or didactic methods, such as videos, multimedia formats, or online coursework [14]. These approaches, while informative, frequently lack the incorporation of practical, real-world assessments and simulations, which are crucial for preparing staff for the complexities of actual encounters [15,16].

Traditional training can be enhanced with role-play with actors, peers, or individuals with lived experiences [15,17,18], but such methods can be logistically challenging and costly [19]. This logistical burden can limit the frequency and depth of training.

Virtual reality (VR) training has emerged as a promising alternative to bridge theory and practice in a wide range of fields [20–23]. VR's ability to simulate real-life scenarios offers a unique opportunity for staff to engage in realistic, practical training without the associated risks of real-life confrontations. With its immersive nature, VR allows for realistic simulations of complex scenarios, typically using engaging VR experiences while providing a safe and controlled environment for failsafe practice and learning [24,25].

VR's immersive qualities align with key learning theories that underpin experiential education, such as Kolb's experiential learning theory and situated cognition. Kolb posits that learning is most effective when individuals are actively engaged in a process that involves experiencing, reflecting, conceptualizing, and applying knowledge in real-world scenarios [26]. Situated cognition theory further supports the use of VR, as it argues that knowledge is most effectively acquired when learners are embedded in authentic contexts where skills are directly applied [27]. In the context of disability support, VR can provide staff with a controlled environment to develop and refine de-escalation techniques that mirror real-world challenges.

1.1. Related Works

Aligning with the theoretical foundations of experiential education, growing empirical evidence supports the efficacy of VR training. For example, a recent meta-analysis with 184 included studies and 9007 participants demonstrated the superiority of VR training over traditional training methods [20]. This efficacy is particularly evident in healthcare, where VR has emerged as a powerful tool for improving medical education and clinical care [28–31].

VR enables the simulation of a broad range of medical procedures, allowing practitioners to develop technical skills without compromising patient safety. For instance, studies have shown that VR-based surgical training significantly improves implant placement accuracy while reducing procedural completion time [30]. Beyond procedural and technical proficiency, VR has demonstrated significant potential in fostering essential non-technical skills in healthcare professionals. This includes the development of empathy [32], communication [33], and clinical decision making [34], all critical for delivering high-quality patient care. For example, VR simulations of conditions like schizophrenia have been shown to enhance empathy and improve attitudes towards people with schizophrenia among higher-education health students [35].

The safety of virtual environments also provides an ideal platform for handling more challenging scenarios, such as interpersonal conflicts and situations requiring de-escalation. Recent studies have demonstrated the effectiveness of VR in training various professionals in de-escalation techniques across different sectors.

In healthcare, VR-based curricula have shown significant improvements in conflict communication skills and self-efficacy among clinicians [36]. An exploratory study demonstrated the feasibility of using VR for de-escalation training, finding that verbal interaction with a virtual agent in a VR-based de-escalation trainer was well received and feasible for training staff from various clinical backgrounds [37]. Extending to specialized care, VR training shows promise for enhancing caregivers' ability to de-escalate responsive behaviors in persons with dementia [38].

The law enforcement sector has also seen promising results. VR training for police mental health crisis response has been found to be equally effective as live-action scenario training in improving de-escalation skills, with the added benefit of showing a greater reduction in bias towards mental illness [39]. Combining full-body VR training with physiological monitoring for police officers was positively perceived by participants, with the physiological measures providing valuable insights into stress responses and decision-making processes during high-pressure situations [40].

VR's versatility extends to other professional contexts as well. It has been explored for training public transport employees in verbal de-escalation [41]. In the educational sector, preliminary results suggest that library and information science graduate students benefit from VR training, showing increased knowledge, empathy, confidence, and de-escalation skills when interacting with patrons in crisis [42].

While healthcare professionals already use VR to improve medical education and clinical care [28,29,43], its application in the neurodiversity support training sector is still gaining momentum. For instance, a study investigated a custom-built VR program to foster empathy in disability workers by immersing them in the first-person perspective of having an intellectual disability [44]. Another study examining staff perspectives on VR adoption for neurodivergent individuals revealed optimism about its potential benefits but also highlighted barriers such as financial constraints and knowledge gaps [45]. While there is a significant number of studies related to use with clients of disability support organizations [46–50], research focusing on staff training in this area remains limited.

Collectively, these studies highlight VR's capacity to provide realistic, immersive scenarios for practicing de-escalation skills across various fields. However, there remains a significant gap in research specifically addressing VR-based de-escalation training for staff working with neurodiverse individuals in disability support settings. This gap is particularly noteworthy given the unique challenges and communication needs often present in these environments.

1.2. Current Study

Building on the potential of VR in educational contexts, the primary aim of this study is to develop and evaluate a bespoke VR application specifically tailored for de-escalation training in disability support settings, with a particular focus on clients with neurodevelopmental disorders. By doing so, we aim to enhance practical skills, foster empathy, and ultimately improve the safety and well-being of both staff and clients in these critical environments.

This study was systematically divided into three stages to ensure a comprehensive development process:

- Stage 1: Creating content and developing the VR prototype

The first stage was dedicated to curating content that mirrors real-world de-escalation scenarios, alongside the development of the VR prototype. This involved designing virtual clients, the virtual environment, and a scoring mechanism.

- Stage 2: Expert content validation

During the second stage, the initially developed content was validated by a panel of 12 experts specializing in de-escalation and related areas. Their comprehensive feedback and ratings were essential in refining the VR application and ensuring its alignment with real-world scenarios in disability support settings.

- Stage 3: Piloting VR application

The final stage involved pilot testing the VR application to assess usability and establish preliminary evidence for its construct validity in a sample of 20 participants.

The subsequent sections will detail the methodologies and outcomes for each stage, followed by a general discussion of the overall findings.

2. Stage 1: Creating Content and Developing the VR Prototype

Stage 1 (June 2022 to May 2023) focused on developing realistic scenarios for de-escalation training. The development was informed by an iterative process with input from disability support providers and crisis intervention experts. The concept for the VR tool originated from discussions with a National Disability Insurance Service (NDIS) provider in South Australia, which highlighted a pressing need for enhanced training in managing escalating behaviors, with a specific emphasis on realistic practice opportunities.

The primary goal of this stage was to develop a VR prototype that could be used for de-escalation training. We aimed to draft three diverse training scenarios that would form the core of the VR de-escalation training program. These scenarios were designed to safely build skills in simulated challenging interactions and allow users to apply de-escalation techniques in a controlled, virtual environment.

2.1. Methodology

The methodology for Stage 1 encompassed several key components in developing the VR prototype for de-escalation training. This process involved creating realistic scenarios, designing virtual environments and clients, developing a structured flow for user interactions, establishing a scoring system, and implementing the technical aspects of VR development. The methodology was grounded in an iterative approach and included discussions with disability support providers, literature search, and the research team's experience. This section details the critical scenario elements, interactive stages, and scoring that underpin the virtual training experience.

2.1.1. Scenario Elements

Each scenario is composed of several key elements that, when combined, create a comprehensive and immersive experience. The key elements in each scenario are as follows:

- Model of assisted living house: A virtual environment was generated to impart a real-world context to the scene, representing a 1:1-scale replica of an assisted living house. This choice was made to simulate the environment encountered by care support providers in their professional settings (see Panel A, Figure 1). To ensure accuracy, the environment was modeled with reference to building schematics/floor plans. The virtual client also engages with aspects of the environment throughout the experience.
- Scenario background: This sets the stage with environmental and interpersonal information that lays the groundwork for potential escalation triggers. For example, "Your 17-year-old client, Joseph, has a curfew and is not allowed out of the house past 9:00 p.m. You overhear him speaking on the phone about meeting his friends outside at 10:00 p.m.".
- Client background: This provides information on each virtual client, such as personality traits, preferences, or behaviors. This equips users with the necessary insights for informed de-escalation strategies. For example, "When Joseph gets frustrated, he has a tendency to display physical aggression".
- Virtual clients: A virtual representation of a client was created for each scenario. The virtual clients were designed to represent a diverse range of individuals who differ

in race, age, and gender. These virtual clients were also programmed to display varied behaviors and responses (see Panel B, Figure 1). For example, the virtual client "Joseph" is a young adult male with good language skills. Depending on the participant's choices, "Joseph" will either end the scenario by sitting down and watching television or he will throw an object at the television. Each avatar has five distinct reactions.

- Prompts: This details the virtual client's immediate actions or statements, prompting user responses. For example, "Joseph is putting on his shoes and jacket, getting ready to leave the house. How do you respond"?
- Responses: These allow users to choose from five options in reaction to the prompts, incorporating possible actions and statements. For example, "I understand you want to see your friends tonight. However, your safety is my main priority. Let's discuss this further".

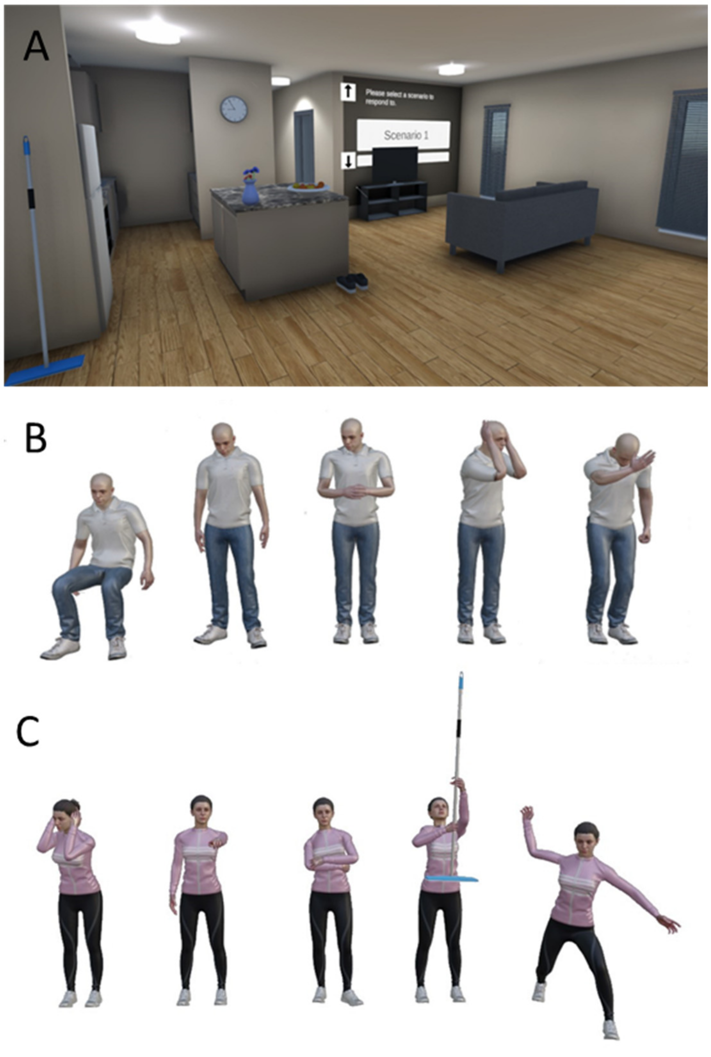

Figure 1. Elements of the VR scenario. (**A**) Top Panel: Screenshot of the modeled housing environment where the scenarios occurred. (**B**) Middle Panel: Example of varying stages of interaction with virtual client 'Kevin' who exhibits self-harm behaviors. From left to right, the sequence of standstills illustrates Kevin's behavior spectrum: 'Sitting down' (most positive), 'Nodding', 'Fidgeting', 'Covering ears', and 'Hitting self' (most distressed). (**C**)—Bottom Middle Panel: Behavior spectrum of virtual client Nicole (non-verbal, aggression to environment): 'Covering ears' (most left), 'Pointing at activity board', 'Angry stance, stomping, hands on hips', 'Breaking light', and 'Throwing objects' (most right).

The creation of responses was informed by the English-modified De-escalating Aggressive Behavior Scale (EM-DABS) [51], which delineates seven key attributes of effective de-escalation.

2.1.2. Scenario Structure and Flow

Each scenario begins at an initial neutral stage that serves as a starting point where users are presented with a situation and must select their first response. Based on their choice, users will then progress to either the positive (de-escalating) or negative (escalating) pathways. Each path contains two additional response stages (see Figure 2).

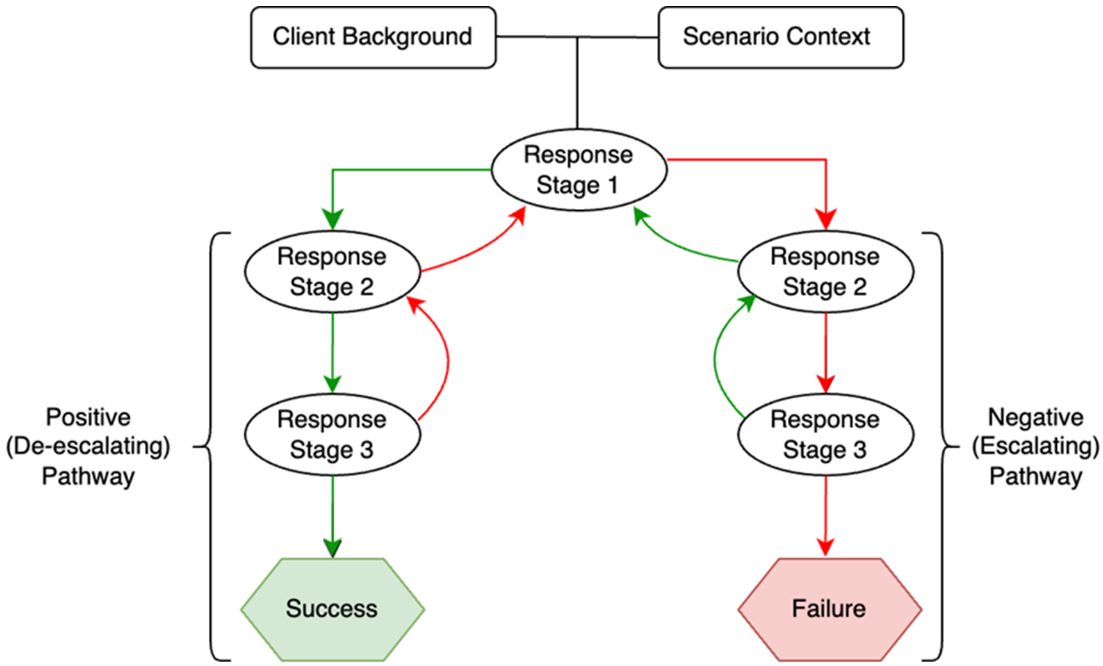

Figure 2. Scenario structure and flow. Start point for each scenario is Response Stage 1. Green arrows indicate the selection of a de-escalating response, while red arrows indicate the selection of an escalating response. For example, if a user selects an escalating response in Response Stage 2 on the negative pathway, they move to Response Stage 3. If they select a de-escalating response, they move backward to Response Stage 1 of the negative pathway.

Users progress along a path depending on the responses selected. For example, if a user reaches Stage 3 on the positive path but chooses an escalating response, they will return to Stage 2. It is also possible to transition between paths. For example, if a user reaches Stage 2 on the negative path but chooses a de-escalating response, they will return to the initial stage. From there, they can switch to the positive pathway if they pick a de-escalating response.

2.1.3. Scoring Logic and Scenario Completion

Participants start with a score of 15 points. All response stages feature five options, including two de-escalating (−1 point) and three escalating (−2 points). Scores are accrued across all selections. Scenarios end if one of the following applies:

- Selection of a de-escalating response at Stage 3 of the positive pathway;
- Selection of an escalating response at Stage 3 of the negative pathway;
- Participant score reaches 0 or below (automatic end).

As such, the possible score range for a single scenario is between 0 (worst) and 12 (best possible score).

2.1.4. VR Software and Development

The VR training tool was built using Unity (v.2021.3.5f1, San Francisco, CA, USA), a cross-platform game engine. The 3D environmental elements were modelled using Blender (v.3.1). Blender was also used to create custom animations displayed by the client avatars. Character models (avatars) and animations were obtained from Mixamo (San Francisco, CA, USA), an open-source 3D modelling and animation content provider. This development environment enabled the creation of immersive, interactive VR training content from graphical assets through coding-based game logic.

2.2. Results and Discussion

The first stage of this research focused on creating prototype VR training scenarios and interactive components to enable immersive de-escalation practice that emulates real-world situations. Attention was placed on ensuring the ecological validity of situations, inclusive representation across client profiles, and basing responses on best practices by applying EM-DABS attributes for de-escalation [51], the literature, and the research team's expertise. The iterative development led to content in three key domains:

- Virtual clients: Three clients were modeled, depicting teens and young adults, backgrounds, and disabilities. They were designed with triggers and escalation responses observed in the real world to provide exposure to representative individuals within the support system.
- Scenario development: Three scenarios were scripted and set in a housing environment. In Scenario 1, a teenager, Joseph, contemplates breaking household curfew rules for the first time. The scenario requires a preventative resolution. Scenario 2 features maintenance work being undertaken in a client's room. The loud noises trigger agitation and introduce an environmental factor contributing to escalation. Scenario 3 shows a client named Nicole who is distressed following a dentist appointment. The scenario represents escalation originating from a previous difficult experience. The selected trigger situations align with categories shown to elicit behavioral escalations [52].
- Response options and scripting: Ten potential textual responses were drafted per scenario prompt, double the number ultimately required in the final program. Drafting this expanded initial set allowed for the selection of the most effective and appropriate responses based on expert input in Stage 2.

The above assets were integrated within an initial VR application prototype depicting the virtual clients in modelled housing environments. Users could interact by viewing prompts, selecting response options, and seeing the virtual client's corresponding reaction to the chosen option.

3. Stage 2: Expert Content Validation

Expert validation is an essential standard in assessment design [53]. It involves reviewing content for its relevance and representativeness. In this stage, professionals in disability support appraised scenario triggers, client profiles, escalation patterns, and responses developed in Stage 1. The aim was to refine and finalize the scenarios for pilot testing in the project's final stage.

3.1. Methodology

3.1.1. Participants

Twelve participants (three women) with expertise in support and de-escalation were recruited for this study, including support workers, managers, behavioral practitioners, and CEOs/directors of NDIS providers. Recruitment was conducted through social media posts and by sending study flyers to the researcher network. Eligibility required being over 18, having at least two years of experience in care support and certification in de-escalation/crisis prevention, as well as a current role in disability support. Ethics approval was obtained from the University of South Australia, and all participants provided written informed consent prior to participation.

3.1.2. Materials

A survey (Qualtrics, Provo, UT, USA) was developed to collect expert feedback on the VR scenarios in June and July 2023. The initial section of the survey collected participants' descriptive information, including gender and occupation. The quantitative feedback was gathered in three sections.

1. Scenario context and client background: Participants assessed the plausibility and respectfulness of scenario contexts and client backgrounds on a 7-point Likert scale, rating each from 'highly implausible' to 'highly plausible'.
2. Response stages: Participants reviewed and rated response-stage content for plausibility and de-escalation effectiveness. Ratings for each of the ten response options per stage used a 1 to 100 slider scale, from 'highly escalating' to 'highly de-escalating'.
3. Overall suitability: Participants provided an overall scenario rating, considering aspects, like flow, realism, and training suitability, on a 7-point Likert scale, from 'not suitable' to 'highly suitable'.

Additionally, qualitative feedback was sought throughout the survey through open-ended questions. Queries such as 'How could this scenario be made more realistic?' and 'Do these responses cover a wide range of de-escalating effects?' provided insights into the content's suitability and areas for enhancement.

3.1.3. Procedure

Participants partook in approximately 30 min sessions to evaluate and critique a randomly assigned VR scenario. Following consent, confidentiality assurances, and entry of basic personal information, participants accessed the survey, prompting both quantitative ratings and qualitative feedback on the content. Concurrent think-aloud verbal feedback was recorded for supplementary qualitative analysis.

3.1.4. Analysis and Decision Making

The quantitative analysis involved calculating means and standard deviations for all assessed content facets, such as plausibility, respectfulness, responses, and suitability for training. For each response stage, the ten draft options were ranked from most de-escalating to most escalating based on expert numerical ratings. The top two and bottom three responses were selected for inclusion to provide a clear distinction between favorable de-escalating and unfavorable escalating approaches.

Transcripts of the verbal feedback were analyzed to identify concerns and suggestions for improvements.

Decision making regarding modifications to scenario content was based on a consensus approach. A group of 3–4 researchers evaluated the findings by considering both the quantitative metrics (means and standard deviations) from expert ratings and the qualitative feedback. This ensured that decisions were data-driven while also accounting for nuanced expert insights. All decisions were made with at least 75% agreement among the researchers.

3.2. Results and Discussion

This section outlines the outcomes and subsequent modifications of the three VR scenarios developed in Stage 1, as determined by expert evaluation. The focus was on enhancing the scenarios' realism, appropriateness, and educational value for disability support training. Scores for each scenario and response are available as Supplementary Material. Based on the evaluations, two scenarios were identified as meeting the required standards and were approved by the experts for progression to the pilot testing phase.

3.2.1. Scenario 1

Scenario 1 achieved consistently strong ratings across key quantitative measures, including plausibility (M = 6.14; SD = 0.63), respectfulness (M = 5.5; SD = 1.12), and suitability for training (M = 6.0; SD = 1.22), on 7-point Likert scales. The limited variability and above-average scores indicate general expert consensus on clear realism and appropriateness.

Qualitatively, an expert raised concerns about the phrasing 'When Joseph gets annoyed, he has a tendency to display physical aggression,' noting its potential to reinforce stereotypes by linking aggression directly to disability without considering other influences. After careful consideration, the research team chose to retain this language. This decision was based on the scenario's specific focus on providing contextual background for de-escalation responses rather than a comprehensive exploration of the factors influencing individual behaviors. However, this decision was made while acknowledging the complexity of such representations and the importance of avoiding generalizations in broader contexts.

The strong ratings and commentary otherwise affirmed the existing content without necessary further changes.

3.2.2. Scenario 2

Scenario 2 achieved mixed quantitative ratings, with metrics including a low context plausibility score (M = 4.0; SD = 2.24), moderately high background respectfulness (M = 6.0; SD = 0.71), and moderate perceived suitability for training (M = 4.75; SD = 1.30) on 7-point scales. Concerns were raised due to the low means and high standard deviations for plausibility.

Qualitatively, a strongly contradictory spectrum of feedback emerged, with one expert commenting on plausibility: "Yeah, seven (out of seven). Highly plausible". However, others raised implausibility: "It just wouldn't happen (referring to scheduling issues) . . . We'd organize for it [to] happen at a time they weren't at home".

Overall, the lack of consensus combined with multiple lower marks led to the decision to exclude this scenario for further development.

3.2.3. Scenario 3

Scenario 3 garnered positive quantitative ratings, with averages reaching 6.11 (SD = 0.84) for plausibility, 5.0 (SD = 0.71) for respectfulness, and 6.25 (SD = 0.83) for suitability on 7-point scales. The higher marks and limited dispersion indicate solid expert confidence.

Qualitatively, commentators applauded the realistic potential and value for disability training and its "good potential to show new staff what the reality (of working in disability support) is".

The only concern surrounded the prompt "Nicole covers her ears and says the word lamp", with experts noting that a non-verbal client would be unlikely to communicate multiple needs simultaneously across different modes like gestures plus speech. Accordingly, researchers modified the prompt to "Nicole covers her ears", removing the simultaneous speaking element. With this adjustment, Scenario 3 was approved for inclusion in the VR application.

4. Stage 3: Piloting VR Application

With the scenarios refined, Stage 3 aimed to pilot test the developed VR de-escalation training application. The focus was on testing its usability. Evaluating usability was imperative, as unsatisfactory user-friendliness severely hinders adoption due to factors like frustration navigating poorly designed interfaces [54]. To this end, the System Usability Scale [55] was employed to assess the overall quality of the user experience.

Additionally, this stage sought to gather initial evidence of the tool's construct validity, particularly in relation to empathy. Empathy is identified as a crucial component in de-escalation, with research suggesting a link between empathy levels and effective conflict management [56–59]. Given this link, we examined the relationship between participants' performance in the VR scenarios and their scores on the Toronto Empathy Scale [60]. The convergence of VR performance scores with established empathy measures would offer an indication of the tool's construct validity.

4.1. Methodology

4.1.1. Participants

Twenty participants (ten female) aged 19–38 years (M = 22.8, SD = 4.48) were recruited for this pilot study conducted in August and September 2023. Recruitment was conducted through multiple channels, including flyers posted on the university campus, social media posts, and an online participant database. The sample primarily comprised undergraduate students from diverse academic backgrounds: Psychology and Social Sciences (n = 11), Medical and Health Sciences (n = 3), Business and Management (n = 3), Engineering and Technology (n = 2), and Arts and Design (n = 1). Seven participants reported prior experience working with individuals with neurodevelopmental disorders. For most participants, this study represented their first experience with immersive virtual reality technology.

Exclusion criteria included any self-reported personal history of post-traumatic distress tied to violence/aggression or previous problems with cybersickness to minimize the potential risks of interacting with confrontational VR content.

All participants provided informed written consent, with ethics approvals granted by the Human Research Committee of the University of South Australia.

4.1.2. Questionnaires

The System Usability Scale (SUS) is a widely used tool for assessing the usability of a variety of systems and products [55]. It consists of a 10-item questionnaire, and its composite scores range from 0 to 100, with higher scores indicating better usability. An accompanying adjective rating scale categorizes SUS results into descriptive tiers, with scores above 85 being classified as 'Excellent' and scores above 71 being considered 'Good' [61].

The Toronto Empathy Questionnaire (TEQ) is a commonly used tool for assessing empathy [60]. Comprising 16 items, each item is rated on a 5-point scale (0 to 4), with the total score ranging from 0 to 64 and higher scores indicating higher levels of empathy.

4.1.3. Materials

VR scenarios 1 and 3 developed in Stage 1 and refined in Stage 2 were employed. For detailed information on these scenarios' flow, structure, and scoring, please refer to Section 2.1.

The scenarios were delivered using the Meta Quest Pro headset (Reality Labs), and participants interacted with the virtual environment using the Meta Quest Touch Pro Controllers.

4.1.4. Procedure

Upon arrival at the dedicated study room, participants received a comprehensive briefing on consent procedures, confidentiality, and the study's objectives. After providing written informed consent, participants completed the Toronto Empathy Scale. Subsequently, they underwent a detailed orientation on the Meta Quest Pro headset usage and associated safety protocols. This was followed by a one-minute acclimatization period in the virtual environment to ensure comfort with the VR setup.

Participants were then instructed on how to navigate the VR program and select responses. Each participant engaged in two scenarios, with the sequence counterbalanced. Client background information was provided verbally, while scenario context, prompts, and response options were displayed within the application. Participants used the controllers to select their responses.

Upon completion of both scenarios, participants filled in the System Usability Scale. As compensation for their participation, each participant received AUD 15.

4.1.5. Results and Discussion

The mean SUS total score was 81.0 (SD 10.7), see Figure 3. A one-sample *t*-test comparing this score against a benchmark of 71, the threshold for 'good' usability [61], indicated a significant difference, $t(19) = 4.19$, $p < 0.01$, Cohen's $d = 0.93$. This result suggests that the VR application's usability not only meets but significantly exceeds the established standard for 'good' usability, highlighting its high level of user-friendliness.

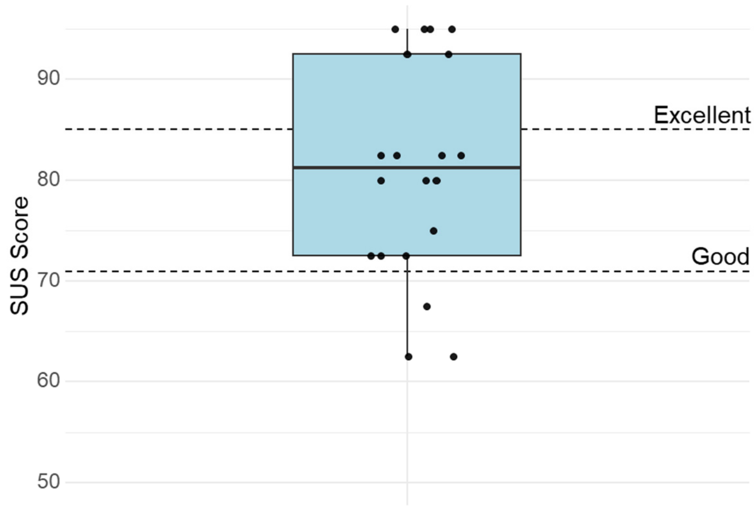

Figure 3. Boxplot and individual data of SUS scores with cut-offs for Good and Excellent system usability scores according to [61].

For the Toronto Empathy Questionnaire (TEQ), the average score was 47.5 (SD 6.44), while the combined scores from the VR application scenarios averaged 21.3 (SD 4.23). A key finding was the significant positive correlation between TEQ scores and VR application performance, Pearson's $r = 0.487$, $p = 0.035$. This outcome indicates that participants with higher empathy levels, as measured via the TEQ, tended to perform better in the VR scenarios, suggesting some initial evidence for the construct validity of the newly developed VR application.

A notable observation was the lack of a significant correlation in performance across the two scenarios (Pearson's $r = 0.167$, $p = 0.493$). This may indicate that each scenario taps into different aspects of de-escalation skills. Such a finding underscores the importance of developing a diverse range of scenarios within de-escalation training programs to comprehensively cover the entire construct of de-escalation and its requisite skills. This variety is critical to ensure that trainees are exposed to and can develop a broader de-escalation skill set.

While the findings from this pilot study are highly promising, it is important to recognize that they represent only the first step in evaluating the effectiveness of our newly developed VR application. The relatively small sample size necessitates caution in generalizing these results. Additionally, the overall high performance in the VR tasks suggests a potential ceiling effect, indicating that the scenarios may not be sufficiently challenging for all users.

Future iterations of the program might benefit from adjusting certain response options to increase the difficulty level, thereby avoiding potential ceiling effects, and ensuring that the training remains robust and challenging for a wider range of users. Alternatively, enhancing the training program could involve categorizing scenarios by difficulty level and treating them as modular components. Participants could start with simpler scenarios and progressively work their way up to more challenging ones. This modular, escalating approach would cater to varying skill levels and facilitate continuous skill development, potentially enhancing the tool's effectiveness in developing complex de-escalation skills and contributing to more comprehensive training experiences.

5. General Discussion

This study initiated the development and validation of a VR application for de-escalation training, specifically targeting interactions involving teenagers and young adults in disability and community-supported living environments. The process was methodically divided into three stages: scenario development, preliminary content validation by experts to ensure realism and appropriateness, and a pilot testing phase. The pilot test underscored the application's good usability and suggested a positive correlation between empathy levels and VR performance.

This research aligns with and builds upon the existing VR training literature [20,21,28,29] by building specialized VR training focused on disability support staff. In line with previous studies exploring verbal de-escalation in clinical environments [37] and responsive behavior management in dementia care [38], this research highlights the potential of VR in specialized de-escalation and positive behavior support training for disability support professionals.

The usability findings from the pilot test of our VR application, as assessed via the System Usability Scale, showed promise, particularly among our relatively young participant group. However, the extent to which these results can be generalized across different ages and levels of technological literacy remains an open question for further exploration. Despite the positive usability ratings in this study, the reliance on controllers for selecting text-based responses does not reflect natural human interactions. To improve this aspect, future iterations could consider integrating AI-based conversational agents [62] for more intuitive verbal engagement, thereby better mirroring natural conversations. Early adopters of conversational agents for de-escalation purposes have noted challenges with voice recognition, such as accent detection [37]; however, the rapid advancement in AI-based conversational agent technology is promising [62]. These developments suggest that more natural and effective interactions in VR training environments are attainable in the near future and could significantly enhance the overall training experience.

The initial gathering of construct validity evidence in this study was a crucial stepping stone for the continued development and validation of our VR training tool. This foundational work sets the stage for two critical paths forward: enhancing the tool's comprehensiveness and defining its role in training curricula.

For the tool's ongoing development, the primary focus must be on creating a broad spectrum of scenarios and cases. This diversity ensures the tool addresses the multifaceted nature of de-escalation, providing participants with realistic and varied situations to navigate. Determining if the tool will primarily function as an assessment instrument or a comprehensive training module is also essential. If it is the latter, developing complementary educational materials is imperative. These could include lectures or resources that provide the theoretical basis of de-escalation, upon which the VR tool can then allow users to apply this knowledge in simulated practice scenarios.

A critical step for the tool's ongoing validation will be to integrate it into training curricula and compare its effectiveness and impact on learning outcomes to current training methods. Comparative studies with traditional training methods will provide valuable insights into the VR tool's effectiveness, user engagement, and overall impact on the quality of de-escalation training.

These two steps will be pivotal in evolving the VR tool from a promising prototype to a validated, effective training resource that can significantly enhance the skill set of professionals in disability support and other related fields.

6. Conclusions

This study represents an important step in the development of a VR application tailored for de-escalation and positive behavior support training in disability support contexts. Key findings include the successful development of a VR prototype with expert-validated scenarios for de-escalation training, the establishment of preliminary construct validity, as evidenced by the positive correlation between empathy levels and VR performance, and promising usability results from our pilot study with the VR application, achieving a "good" usability rating. The initial phase of our research highlighted the potential of VR as a training environment that complements existing pedagogical approaches. The systematic approach used in this study for scenario development can serve as a template for further enhancing and expanding the suite of scenarios, making the training tool more comprehensive.

While still in its formative stages, this research contributes to the evolving landscape of training in disability support. Incorporating immersive technology, VR offers a unique approach to understanding and practicing de-escalation techniques. Future research should include expanding the suite of scenarios to cover a broader range of situations and skills, comprehensive evaluations against conventional training methods to understand the tool's impact on learning outcomes and skill retention, and the exploration of advanced features such as AI-based conversational agents to enhance the realism and effectiveness of the training. These evaluations and developments will be important to confirm VR's promise of elevating the standard of disability support training, potentially leading to more effective and empathetic care in challenging situations. As we continue to refine and validate this tool, we anticipate its growing role in preparing disability support professionals to handle complex, real-world scenarios with confidence and skill.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/mti8110100/s1, Results of Stage 2.

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