Enhancing User Comfort in Virtual Environments for Effective Stress Therapy: Design Considerations

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Abstract—Mental stress has emerged as a widespread concern in modern society, impacting individuals from diverse demographic backgrounds. Therefore, exploring effective methods for therapy, such as virtual environments tailored for stress management, is vital for advancing mental health and improving coping strategies. Prioritising user comfort in the design of virtual environments is essential for enhancing their efficacy in alleviating stress. By considering four design aspects of virtual environments that influence user comfort: (i) visual clarity, (ii) safety features, (iii) cognitive preparedness, and (iv) social support, this study intends to (i) evaluate the effectiveness of these four user-centered design elements in facilitating stress reduction and (ii) explore the underlying rationale behind their stress-reducing properties. This study utilised a mixed-methods approach comprising (i) experiments, (ii) questionnaires, and (iii) interviews. Following evaluation with the Depression Anxiety Stress Scale (DASS), 40 participants (10 men and 30 females) were chosen from the 55 healthy adults aged 20 to 60 who volunteered for the study. The findings validated the efficacy of all four design aspects in enhancing users' comfort during therapeutic sessions in virtual environments. This study offers important insights not only into the importance of user-centered design in creating virtual environments for stress management, where comfort markedly improves therapy outcomes but also contributes valuable knowledge to the fields of mental health and human-computer interaction, paving the way for further exploration of innovative therapeutic solutions for mental stress.

Keywords—*Virtual environment design; virtual reality; stress therapy; user comfort*

I. INTRODUCTION

Mental stress is now more prevalent than ever, affecting different demographic groups in several nations around the world [1], [2], [3], [4]. Afterwards, traditional therapeutic methods, for example, breathing exercises, progressive muscle relaxation, and guided imagery are often used to treat psychological pressure [5], [6]. Although these traditional therapeutic methods have been effective, they are also associated with several constraints such as low immersion, inadequate engagement, and high levels of contextual distractions. So, virtual reality (VR) technology; as one of the recent new devices has been applied in stress therapy sessions due to its advantages such as being more immersive, attractive, and less environmental distractions [7], [8]. Studies supporting the practical application of VR as therapeutic mechanisms have largely produced positive results, with users self-reporting decreased levels of stress following sessions [9], [10], [11], [12], [13].

Although these effects are positive, literature on the effectiveness of VR for stress therapy (e.g., [14], [15], [16]), focuses much more heavily on whether or not these systems can reduce stress, but leave out a discussion on design factors that are fundamental for the virtual context which enables this process of stress reduction to take place [17], [18]. Following that, [18] suggested eight design requirements for psychological therapy VR applications, whereby one of them is the importance of creating meaningful therapeutic spaces, underscoring the need to develop virtual environments that foster an appropriate therapeutic milieu and address users' emotional needs.

Furthermore, the studies in [19] and [20] in their scoping review of VR environments for stress reduction and management have similarly suggested that more attention should be given to the virtual environment design to promote stress reduction according to user-specific requirements. Their claim is consistent and relevant to the present study, which also prioritizes user comfort in the design of virtual environments for effective stress therapy. In the meantime, [17] proposed a framework that outlines factors and design elements pertinent to virtual environments used in stress therapy, particularly those affecting user comfort. Their framework addresses five factors and fourteen design elements: (i) visual clarity; (ii) safety features; (iii) mind preparedness; and (iv) social support. By referring to their framework, this study aims to (i) evaluate the effectiveness of these four user-centered design elements in facilitating stress reduction and (ii) explore the underlying rationale behind their stress-reducing properties.

Understanding and implementing these design elements is essential not only for the immediate benefits of stress reduction but also for the long-term development of more effective virtual therapeutic solutions. By tailoring virtual environments to meet the specific psychological and emotional needs of users as stated by [21], this study posits that researchers and developers can create more responsive, effective, and user-friendly virtual therapeutic environments that can adapt to diverse user populations.

Moreover, this study bridging theoretical design principles with practical applications fills an important gap in the fields of mental health and human-computer interaction and makes explicit contributions to both disciplines. Indeed, the findings of this study help lay the groundwork for future research on innovative therapeutic solutions for mental stress. Thus, this study not only contributes toward future research but also allows a way to pair interdisciplinary collaboration with state-of-the-art

technologies in treatment approaches, further improving the treatment landscape of mental health issues.

The remainder of this paper is structured as follows: Section II reviews existing studies on virtual reality-based stress therapy and highlights the identified gap. Section III presents a framework for designing virtual environments for stress therapy. Section IV outlines the methodology, including data collection and analysis methods. Section V presents the results, followed by a discussion in Section VI and a conclusion in Section VII.

II. REVIEW OF EXISTING VIRTUAL REALITY-BASED STRESS THERAPY STUDIES

VR use in stress therapy to date has proved beneficial for its users as numerous scholars (e.g., [9], [10], [11], [12], [13]) have proved that VR-based stress therapy yields significant improvements after a session when compared to standard types of treatment by providing man-altering experiences. Recently, [22] undertook a systematic review and found that out of 50 studies conducted on VR and stress management, 48 studies confirmed the efficacy of VR for this purpose. Not only that, but a study by [14] whose systematic review identified that the 17 studies explore VR and immersive technology in workplace wellbeing also supports VR as a safe and effective tool for wellbeing stemming from stress. In agreement, other studies by [19], [23], [24], and [25] also demonstrated the feasibility of the VR stress therapy initiative.

Meanwhile, although many recent studies indicate VR could be a suitable tool for performing stress therapy, there remains a gap in the study of virtual environments designed for stress therapy [17], [18]. In other words, even though the majority of existing studies presented the results on the effectiveness of the system in reducing stress with design discussion focused on general virtual environment factors such as audio-visual elements, navigation, biofeedback integration, and interaction [19], [22], [26], [27], [28]; however, there is limited discussion on user comfort within the virtual environment.

Following that, this study believed that emphasizing the necessity to incorporate user comfort in the design of virtual environments for stress therapy is essential as it serves as a guideline for developing effective virtual environments that aid in the stress reduction process. This is because the implementation of user comfort in virtual environments will ensure the comfortability of the users while in the therapy session, thereby increasing the users' motivation to continue with the therapy session [29], [30]. Neglecting user comfort in the design of virtual environments for stress therapy may result in ineffective therapy sessions and a loss of interest in continuing the therapy.

III. FRAMEWORK FOR DESIGNING VIRTUAL ENVIRONMENTS FOR STRESS THERAPY

A. Overview of Framework for Designing Virtual Environments for Stress Therapy

Fig. 1 illustrates the framework for designing virtual environments for stress therapy. The development of the framework involved four studies; (i) user requirements, (ii) an existing system review, as presented in study [31], (iii) user evaluation, where the discussion was presented in study [32] and

(iv) an expert review, where the details was presented in study [33]. This framework consists of five factors – environment setting, environment exploration, interaction, attention stimuli, and user comfort; and 14 design elements.

The framework was discussed and evaluated by [17], who found out that (i) the system developed based on the proposed framework was found to be effective, usable, useful, and easy to use and (ii) all 14 design elements proposed in the framework were deemed useful in reducing stress. These encouraging findings suggest that the design elements included in the framework significantly contribute to the stress reduction process and should be considered when designing virtual environments for stress therapy.

Fig. 1. Framework for designing virtual environments for stress therapy. Source: [34]

Among these five factors, three are general factors for virtual environments that have been shown to facilitate stress reduction, as evidenced by studies conducted by [18], [19], [27], [35], and [36]. These three general factors are:

- Environment setting, which includes audio and visual design elements that facilitate stress reduction.

- Environment exploration, which addresses navigation techniques to support stress reduction.

- Interaction, which underscores the design elements for suitable interaction types that aid the stress reduction process.

While the past studies (e.g., [18], [19], [27], [35], [36]) mostly focused on the general factor of the virtual environment while discussing audio-visual elements, navigation, and interaction factors, however, the factor of user comfort remains underexplored. In other words, past studies often overlook the importance of user comfort in enhancing the therapeutic outcomes of virtual environments. Therefore, this paper aims to fill in the gap by exploring effective therapeutic interventions, particularly user-comfort-focused virtual environments for effective stress therapy. This study intends to (i) evaluate the effectiveness of four user-centered design elements – visual

clarity, safety features, mind preparation, and social support – in facilitating stress reduction; and (ii) explore the underlying rationale behind their stress-reducing properties. By discussing the rationale behind the stress-reduction properties of these four design elements, this study seeks to provide an understanding of how the user comfort factor contributes to the effectiveness of virtual environments for stress therapy.

B. User Comfort Factor in Designing Virtual Environments for Stress Therapy

User comfort in the context of designing virtual environments for stress therapy refers to the degree to which users feel psychologically at ease while being in the virtual environment. Four design elements contribute to user comfort namely, (i) visual clarity, (ii) safety features, (iii) mind preparation, and (iv) social support. Table I provides descriptions of each design element.

TABLE I.   DESCRIPTION OF DESIGN ELEMENTS THAT SUPPORT USER COMFORT IN VIRTUAL ENVIRONMENTS FOR STRESS THERAPY

Design Element	Description
Visual clarity	Objects included in the environment should be visually clear to ensure information is correctly delivered. The users should quickly gain the necessary information from the visual presented (easily recognize the objects at first glance), understand what is happening, and what they should do to react accordingly.
Safety features	The environment should provide features that make users feel safe and protected. The environment cannot be dangerous in any sense of appearance, either by using dangerous animals or any setting that can trigger the users to feel anxious.
Mind preparation	A short mind-framing session that involves the users prepares their minds to become aware of the environmental changes before the virtual therapy starts (from the real-world environment to the virtual world environment) and before the therapy session ends (from the virtual world environment to the real-world environment). The pre-therapy mind preparation scene is meant to help the users get ready and focus on the therapy scene. The post-therapy mind preparation scene is meant to set the user's mind to bring the relaxation feel from the therapy session to the real world.
Social support	The presence of avatars who resemble real people provides the opportunity to observe and interact.

Source: [34]

Following the description in Table I, Table II shows the recommendations for the design elements' application in virtual environments for stress therapy.

By referring to Tables I and II, the first design element identified to support user comfort is visual clarity. Visual clarity refers to the comprehensibility of the displayed information within the virtual environment. Information may be presented in various forms, such as images, 3D models, or text, with the primary objective being to ensure that users easily understand the displayed information. For example, a display of flying birds should be instantly recognizable, rather than appearing as jagged moving dots. Similarly, fish in a river should be identifiable at first glance. High visual clarity can be achieved through high-quality graphic elements and appropriate techniques, all while maintaining the system's performance [37], [38], [39].

TABLE II.   RECOMMENDATIONS FOR DESIGN ELEMENTS' APPLICATION INTO VIRTUAL ENVIRONMENTS FOR STRESS THERAPY

Design Element	Application of Design Element
Visual clarity	It is recommended to provide a clear graphic display where users can directly get the necessary information presented by an object. A clear graphic display can be achieved by having high-quality graphics. Graphic quality is usually associated with technical graphic aspects such as the numbers of the polygon, resolution rate, texture quality, and anti-aliasing features.
Safety features	It is recommended to provide the users with space and situations that make them feel safe and protected. It is also recommended to consider safety elements before any objects or situations are included in the environment.
Mind preparation	It is recommended to include mind-preparation activities that guide the users to appropriate meditation practices, such as breathing exercises. In addition, it is also recommended to have two sessions of mind preparation: first, at the beginning (before the therapy environment starts), and second, at the end of the therapy session. As for before the session starts (the pre-therapy session), it is recommended to include a set of breathing exercises containing at least three rounds of breath-in, hold-out, and breath-out instructions. This breathing exercise will prepare the user to be in therapy mode. Whereas, the mind preparation scene before the session ends (post-therapy session) should include a script that reminds the users to maintain the positive feeling they experience all day long. At the end of the script, it is suggested to have a countdown for the user to prepare themselves to take off the head-mounted display (HMD). As the script is being read, no additional relaxing visuals are encouraged to be displayed. The application may continue displaying the therapy environment until the end of the countdown. The application should shut down automatically as the countdown reaches its end.
Social support	It is recommended to include the presence of virtual people who mingle around in the environment. The virtual person or avatar may be portrayed through cyclists cycling around a park, a family having a picnic under a tree, or men jogging around. In addition, it is also recommended to take the distance between the virtual people and the users into consideration. Consideration should be made to include some interpersonal distance between the virtual people and the users to provide comfort and privacy to the users. The distance that is too close may trigger anxiety in the users. Apart from that, the number of virtual people included should also be considered. The number should be in minimal quantity—neither too many that will crowd the environment nor a complete absence, which may cause the users to feel lonely instead. Besides, the physical appearances of the virtual people should also be taken into account. Virtual people should portray proper appearances that suit the user's culture.

Source: [34]

The second design element identified is safety features. Safety features pertain to conditions within virtual environments that provide users with a sense of safety and protection. This design element is essential for preventing adverse effects and ensuring a pleasant therapeutic experience [40]. Implementing safety features involves designing the environment to avoid any dangerous appearances, such as the inclusion of hazardous animals like snakes and scorpions or settings that could trigger

user anxiety. Incorporating soft representations of animals [41], such as fish, rabbits, and ducks to fulfil the safety feature design elements is advisable. Furthermore, it is prudent to evade perilous locations, such as cliffs or higher terrains. In environments that may provoke anxiety, appropriate safety precautions must be instituted. In a beach environment with tumultuous waves, the incorporation of wavebreakers could augment users' perception of safety. In the context of a lookout tower, the incorporation of gates or barriers would decrease the likelihood of anxiety-provoking scenarios. Thus, this study advocates for the evaluation of safety aspects before the integration of any objects or scenarios into virtual environments to establish secure and supportive therapeutic settings.

The third design element contributing to user comfort is mind preparation. Mind preparation denotes the individual's engagement in activities that augment their awareness of alterations in the surrounding environment. To incorporate the mental preparation design element in the virtual environment, it is advisable to integrate activities that direct users through suitable meditation practices, including breathing exercises [42], [43], [44], [45]. Mind preparation can be divided into two parts: (i) pre-therapy and (ii) post-therapy sessions. The two parts are designed to ensure a seamless visual transition for the user from the physical world to the virtual environment before therapy and from the virtual realm back to reality following the session's conclusion. The inclusion of this feature aims to enhance users' consciousness, therefore better equipping them for the next stage of therapy. As individuals enhance their preparedness, the probability of experiencing anxiety during the session diminishes.

The fourth design element identified for user comfort is social support. Social support is defined as the presence of avatars that resemble real people, which provides users with opportunities to observe and interact. The objective of implementing social support is to prevent users from feeling lonely and isolated while also helping to reduce the anxiety associated with being alone in an unfamiliar place [46]. Implementing social support requires the strategic placement of avatars within the virtual environment. The avatars may represent cyclists, families having picnics, or individuals jogging. However, it is crucial to consider the distance between the user and the avatars. The avatars should not be allowed to come too close to the user, as this may cause discomfort; nor should they be placed too far away, which could induce feelings of isolation [47], [48], [49]. The concept of interpersonal distance can be applied to determine the optimal positioning of avatars relative to the user, ensuring a balance that enhances comfort and reduces anxiety.

Having explained the descriptions and recommendations for the application of the four design elements, the next section presents the methodology for evaluating the effectiveness of these elements in reducing stress.

IV. METHODOLOGY

A. Participants

A total of 55 healthy adults aged 20 to 60 volunteered for this study. During the screening session, participants answered questions about their stress levels using the Depression Anxiety Stress Scale (DASS). Only those with a score above 14 or a stress intensity scale of four or higher were invited to experience the virtual environment and be interviewed. Those criteria indicated that participants were experiencing some level of stress. Ultimately, 40 participants met the selection criteria of this study. As illustrated in Table III, 10 are male, and 30 are female. Among these 40 participants, 13 participants are within the age range of 20 to 30 years old, 14 participants an age range between 31 and 40 years, nine participants with an age range between 41 and 50 years old, and four participants with an age range between 51 and 60 years old.

TABLE III.   PARTICIPANTS' DEMOGRAPHIC PROFILES

Demographic Profiles		Frequency	Percentage
Gender	Male	10	25.0%
	Female	30	75.0%
Age	20 – 30 years old	13	32.5%
	31 – 40 years old	14	35.0%
	41 – 50 years old	9	22.5%
	51 – 60 years old	4	10.0%

B. Data Collection

Given that the four design elements to address user comfort were reported to be effective, usable, useful, and easy to use, this study therefore focused on evaluating the usefulness of these four design elements in reducing stress. Three methods were used to collect the required data: (i) experiment, (ii) questionnaire, and (iii) interview. In other words, all 40 participants went through all three data collection methods, beginning with the environmental stage, filling in the questionnaire, and ending with an interview session.

1) Experiment: All 40 participants were invited to this experimental stage, which allowed them to experience the virtual environments developed based on the proposed framework discussed in the earlier section and as an evaluation tool to assess the usefulness of the proposed design elements in a single session. Fig. 2 shows images of the virtual environments used in the experiment.

2) Questionnaire: The usefulness of the design elements was evaluated based on their helpfulness in assisting users in reducing stress. A 5-point Likert-type scale question was included in the questionnaire for participants to rate the helpfulness of each design element in reducing stress where 1 indicated 'not useful at all', 2 'not helping much', 3 'helpful', 4 'very helpful' and 5 'no opinion'.

3) Interview: Upon completion of the experimental session, face-to-face interviews were conducted with each participant. The objective of the interview was to gain a further explanation of the ratings received in the questionnaire. The questions asked during the interview sessions were based on feedback obtained from the questionnaire. Each interview session was audio-recorded for analysis purposes. The interview sessions provided insights into how each design element contributed to the stress reduction process and ensured accurate interpretation of the rating received.

Fig. 2. Images of virtual environments used for the experiment.

C. Data Analysis

Data analysis was conducted based on the type of data collected. Feedback received in numerical form was tabulated on a table and was then analyzed by using descriptive statistical analysis using Microsoft Excel 2021. Meanwhile, recorded audio was transcribed word-by-word before they were reviewed three times for accuracy and understanding and content analysis using ATLAS.ti version 9.

V. RESULTS

The results of the analysis are presented in three parts; (i) helpfulness frequency, (ii) helpfulness mean values, and (iii) helpfulness understanding.

A. Usefulness of Design Elements to Support User Comfort Based on Helpfulness Frequency

The helpfulness of the design elements was assessed using a 5-point Likert-type rating grouped into four categories for analysis purposes as shown in Table IV.

Based on the analysis, this study found the majority of the participants agreed on the usefulness of all four design elements in assisting them to reduce stress. As detailed in Table VI, the agreement is reflected in the high numbers of 'helpful' frequency (3 and 4 helpfulness rating points) compared to 'not helping much', 'not helpful at all', and 'no opinion'.

B. Usefulness of Design Elements to Support User Comfort Based on Helpfulness Mean Values

As shown in Table V, this study also analyses the helpfulness of the design elements that facilitate user comfort through their helpfulness mean values. All four design elements were useful in reducing stress as their helpfulness mean values were above the mean scale value of 2.5.

C. Rationale Behind the Helpfulness of Design Elements in Facilitating Stress Reduction

The analysis of the interviews provided an understanding of how the design elements aid stress reduction as the participants were asked to explain their reasoning behind the helpfulness rating, they provided for the design elements during the interview sessions.

1) Visual clarity: For the first design element, visual clarity, the majority of the participants (39 out of 40 participants or 97.50%) rated it as 'helpful' in reducing their stress – as presented in Table VI earlier. Indeed, the interview participants revealed that this design element is helpful as the clarity of the visual displayed significantly contributed to their comfort. They elaborated that: "Nah… clear visual made it easy to capture the information (displayed)… I didn't have any problem to do that" (Participant 17) and "When it (visual display) clear… it helps us feel at ease and comfortable" (Participant 57).

Meanwhile, for the one who rated visual clarity as 'not helping much', the reason for that was the user claimed to experience an unclear visual display. The participant commented that it was difficult to recognize the information being conveyed, which made her feel uncomfortable. She commented: "*Unclear visual made me dizzy*" (Participant 50).

TABLE IV. DERIVATION OF HELPFULNESS CATEGORIES BASED ON THE HELPFULNESS RATING POINTS

Helpfulness Rating Point	Helpfulness Category
4 - Very helpful	Helpful
3 - Helpful	
2 - Not helping much	Not helping much
1 - Not helpful at all	Not helpful at all
5 – No opinion	No opinion

TABLE V. TABULATION OF DESIGN ELEMENTS' HELPFULNESS MEANS VALUES

Design Element	Mean	SD
Visual Clarity	3.58	0.55
Safety Features	3.55	0.81
Mind Preparation	3.45	0.85
Social Support	3.05	0.99

TABLE VI. TABULATION OF DESIGN ELEMENTS HELPFULNESS CATEGORIES FREQUENCY

Design Elements	Helpful		Not Helping Much		Not Helpful At All		No opinion	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Visual Clarity	39	97.5	1	2.5	0	0.0	0	0.0
Safety Features	37	92.5	2	5.0	0	0.0	1	2.5
Mind Preparation	36	90.0	3	7.5	0	0.0	1	2.5
Social Support	33	82.5	3	7.5	3	7.5	1	2.5

2) Safety features: For the second design element, 37 participants, or 92.5% rated safety features as 'helpful'. Analysis from the interviews revealed that this design element aids in stress reduction by providing them with a feeling of being safe and protected within the virtual environment. The participants indicated that the implementation of safety features made them feel comfortable as the environments appeared to be not dangerous in any aspect, especially due to the absence of dangerous animals. Among comments received highlighting the importance of safety features included: "Felt safe as there were no harmful animals around… for example… in the garden… within that unfamiliar environment, we never know if monkeys might suddenly jumping out of nowhere… that would make me uncomfortable… so, safety elements help in that sense" (Participant 14) and "It helps… in the sense that if there were dangerous animals… there might be surprising elements… causing fear… so… may cause discomfort… unexpected elements don't contribute to relaxation" (Participant 15).

On the other hand, for the two participants who rated safety features as 'not helping much', the analysis revealed they preferred being in an adventurous setting to reduce their stress. These participants mentioned that they did not mind the inclusion of dangerous animals or extreme situations in virtual environments as that would help them better release stress.

3) Mind preparation: For the third design element, mind preparation, 37 participants, or 90% rated it as 'helpful' due to three reasons; (i) it helps to prepare for visual transitions, (ii) it aids first-time users to calm down and (iii) it helps to release mental burden. Besides, they also recommended this study to apply this design element in two parts; (i) pre-therapy scene and (ii) post-therapy scene. These recommendations received positive feedback from the participants believed that mind preparation had assisted them in preparing themselves for visual transitions. Visual transitions meant by the participants referred to the transition from the real world to the virtual environment and from the virtual environment back to the real world. They praised the implementation of this design element as it smoothens the process and reduces the possibility of dizziness. They narrated that: "It helps!!!... It's kind of providing preparation… mental readiness… before we went into it (therapy scene)" (Participant 8), "It is helpful… it provides readiness before we started (therapy scene)" (Participant 12), "Cause it sets our mind…it sets our readiness" (Participant 15) and "It's 100% helpful because it gets you in the state of mind before you go into the simulation (therapy scene)" (Participant 16).

Another rationale for the helpfulness of mind preparation in supporting user comfort within virtual environments for stress therapy was the design element's ability to help first-time users calm down. Some participants mentioned that the experiment sessions were their first experience with VR, making them nervous as they did not know what to expect from the virtual environments. According to them, this is the part where mind preparation helped the most, to ease their feelings and calm them down. Comments reflecting the helpfulness included: "For me personally, it helps… as I don't have any experience with VR beforehand… therefore, the breath in breath out activities… the

preparation exercise… really helped me feel more at ease" (Participant 13), "This one (mind preparation) is actually really helpful…you know when someone has never had any experience with VR… they don't know what to do… starting the therapy session (scene) straight away… is not proper… this thing (mind preparation) is important before we start any therapy… we calm ourselves first" (Participant 14), and "Helpful to reduce my nervous feeling… I had no idea what was inside the environment (therapy scene) … hence… breathing in and out calmed me" (Participant 34).

Additionally, mind preparation was found to be helpful as the design element helps to release the participant's mental burdens. Such practices not only promote relaxation but also empower individuals to enter the virtual environment with a clearer, more focused mindset, ultimately enhancing their therapeutic experience. One participant commented: "Deep breathing in and out made me feel relieved… free of burdens" (Participant 35).

Despite the positive feedback, mind preparation also received three 'not helping much' ratings. Based on the analysis conducted, two reasons were identified. The first reason that caused mind preparation to be less helpful was the participant mentioned that he was more eager to know what was offered in the therapy scene. The eagerness made him restless and uninterested in the mind preparation scene. He commented: "Wanted to skip it (mind preparation scene) as I was more interested in what was offered in the environments (therapy scene)" (Participant 19). The second reason for the less helpfulness rating for mind preparation was some participants had the opinion that breathing exercises could be done anywhere, not necessarily before a therapy session. Hence, making it less interesting as a pre-therapy scene exercise.

4) Social support: For the fourth design element, 33 participants, or 82.5%, rated social support as 'helpful'. The interview sessions also revealed two reasons why the participants believed it was able to help reduce stress. The first rationale for social support being helpful is that its implementation helped users from feeling isolated and lonely. They also recommended this study to place the avatars around the environment as they commented that: "People (avatars) around are helpful… empty environment (without avatars) is not a good idea… may cause loneliness" (Participant 14), "Presence of people (avatars) around reduces loneliness" (Participant 52) and "I can see people around me… it helps… I am not alone" (Participant 55).

The second reason supporting the relevance of social support as a helpful design element in reducing stress is it enhances the realism effect. In the participants' context, realism referred to the imitation of real-world settings within the virtual environment. By incorporating social support, participants felt as if they were in the real world rather than a virtual one. In other words, social support may help to increase user immersion. Among comments received highlighting the benefit of social support in imitating the real-world behavior setting were: "Indeed really helpful… presence of people (avatars) made it feel like being in the real world" (Participant 18), "The presence of avatars… it makes I feel like… like… it is… realistic (real world)" (Participant 17) and "It is essential to have people

(avatars) around… if not… it feels weird to be the only one in the world (virtual environment)" (Participant 32).

For the three participants who rated social support as 'not helping much', the result of the analysis revealed that they preferred to be alone to relieve their stress. For those participants, having people around, even in the form of avatars, made them uncomfortable, as if someone was watching them. They narrated that: "It is better to be alone… don't need social support… I prefer to be on my own" (Participant 8), "I think avatars are not necessary… usually… we find peace with views and sounds…not social support" (Participant 10), and "It is not helpful… having people around feels like someone is watching us… I prefer to be alone to relax" (Participant 53).

Analyzing the feedback for 'not helpful at all', such a rating was given due to the appearance of the avatars used in the system for the experiment session which was found to be scary by three participants. Two participants commented: "It is not helpful at all because the people (avatars)… they look scary (Participant 51) and "Because of the people (avatars)… they are too big and scary-looking" (Participant 50). While the other one commented: "When coming close to the people (avatar)… we can see their scary face… ugly" (Participant 39).

VI. DISCUSSION

The analysis of the data gathered from the experiment, questionnaires, and interview sessions demonstrated that the four design elements identified to facilitate user comfort in virtual environments for stress therapy were useful in supporting the stress therapy process. The encouraging findings were supported by the high number of 'helpful' categories frequency received for all four design elements. Additionally, the mean values for the helpfulness also indicate that the proposed design is useful in assisting stress reduction. The encouraging finding is evidenced by the mean value for each of the design elements surpassing the mean value of the scale used which was 2.5.

Furthermore, the explanation provided for the rationale behind how the design elements assist in stress reduction offers an understanding of the significance of implementing these design elements in virtual environments for stress therapy. This study concluded that visual clarity enhances user comfort by efficiently conveying information, rendering it instantly recognizable and identifiable. Further analysis of the 'not helping much' feedback for visual clarity revealed that the unclear display was not caused by the clarity of the visual environments used for the experiment, but rather a personal issue of the participant. For instance, one of the participants disclosed at the end of the interview that she was experiencing eye problems and was about to undergo corrective surgery. The clarification by the participant indicated that the discomfort experienced was not due to the clarity of the environment but the participant's health issue.

For safety features, this study confirmed that this element helps provide user comfort in virtual environments for stress therapy. The helpfulness is attributed to the sense of safety and protection, as safety features encourage developers to consider safety aspects before implementing any objects or settings into virtual environments. However, for the 'not helping much'

feedback received, it was found that the ratings were based on participants' personal preferences rather than their experiences with the system during the experiment before the interview session. Consequently, it may be inferred that the ineffectiveness of the safety features in facilitating stress reduction was attributable to user preferences rather than the characteristics themselves.

Mind preparation was also deemed helpful by the majority of the participants. Based on the results presented, it can be seen that the majority of the participants agreed that mind preparation helped reduce stress. Mind preparation was acknowledged for its benefit in preparing users' minds for visual transitions, assisting first-time users in calming calm and easing their nervousness as well as relieving mental burdens. Regarding the 'not helping much' feedback, comments suggest that breathing exercises can be done anywhere and are not interesting to be implemented as pre-therapy scenes might be due to issues in the implementation strategies of the design element in the virtual environments used for the experiment sessions.

The issues mentioned could be from the design of the scene which might be less attractive or the implementation strategies of the breathing exercise guidelines which used expanding and contracting circles to indicate breath in and out instructions. Therefore, the implementation strategies should be improved to better present the breathing exercise. There is no issue with implementing breathing exercises in the pre-therapy scene as they have been evidenced to be effective in reducing stress as reported by past studies (e.g., [50], [51], [52], [53], [54]).

Similar to the other three design elements, social support also received a majority of 'helpful' feedback. The helpfulness of social support was contributed by its ability to prevent participants from being alone and lonely, as well as enhancing the realism effect of the virtual environment. Despite the positive results, social support was also minorly rated as 'not helping much' in reducing stress due to participants' preferences to be alone when relaxing. The result of the analysis revealed that there was no issue with the environments themselves, rather the preference of the participants did not match the setting of the environments. However, the 'not helpful at all' feedback received provided insight into issues regarding the appearance of the avatars. The problem was not the presence of the avatars but their appearance as the avatars used in the virtual environments for the experiment sessions may have had design issues. It was acknowledged that the appearance may be ugly as the avatars' 3D models incorporated in the virtual environments were not ones with high polygons. Therefore, improving the avatars' appearance is necessary to avoid user discomfort in virtual environments for stress therapy.

The findings regarding the efficacy of the four design aspects in enhancing user comfort in virtual environments for stress therapy were favourable. The majority of users concurred that the proposed design elements were 'beneficial' in alleviating stress. The interview findings elucidated the rationale for the helpfulness of the design features, thereby deepening our comprehension of their role in the stress reduction process. This comprehension is essential as it highlights the importance of integrating user comfort and its design components while creating virtual environments for stress therapy.

VII. CONCLUSION

Exploring effective therapeutic methods, especially user-comfort-oriented virtual environments for stress therapy, is crucial for tackling the widespread problem of mental stress in modern society and improving coping strategies. The findings of this study highlight the critical significance of user-centred design in creating virtual worlds specifically designed for stress therapy, whereby the four recognised design elements that enhance user comfort—visual clarity, safety features, mental preparedness, and social support—effectively mitigate stress. The interviews also clarify how these four design aspects help users in regulating their stress levels.

The findings underscore the imperative to prioritise user comfort in the design of virtual environments for stress therapy. Integrating user comfort into the design process is essential for creating effective virtual settings that promote stress relief. User-centred design advocates for the active participation of users in the design process, ensuring that their needs, preferences, and comfort levels are paramount. The study indicates that when design elements are meticulously incorporated, they not only foster a more immersive experience but also enhance users' emotional and psychological well-being, thereby mitigating mental stress and improving general well-being.

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