Journal of Information Systems Engineering and Management
2025, 10(16s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Content Validity for VR based assessment: Rehabilitation method for children with Cerebral Palsy

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ARTICLE INFO

Received: 05 Dec 2024

Revised: 26 Jan 2025

Accepted: 10 Feb 2025

ABSTRACT

Background: Virtual reality (VR) has emerged as a promising tool in paediatric rehabilitation, offering immersive, interactive environments that engage children and support therapeutic outcomes. For children with cerebral palsy (CP), a neurodevelopmental disorder affecting motor skills and coordination, VR-based interventions can provide engaging exercises tailored to individual needs. However, the clinical adoption and effectiveness of these tools rely heavily on their content validity—the extent to which the elements of the intervention are relevant and representative of the intended therapeutic goals.

Objective: This study aims to evaluate the content validity of VR-based rehabilitation interventions designed for children with CP. A systematic approach was employed, utilizing a panel of multidisciplinary experts, including paediatric orthopaedic surgeon, paediatric rehabilitation therapists and biomechanist. The interventions were assessed based on their alignment with motor, cognitive, and engagement objectives critical to the rehabilitation of children with CP. The content validity ratio (CVR) and content validity index (CVI) were calculated to quantify expert consensus on the essentiality, relevance, and representativeness of the intervention components.

Results: Preliminary findings indicate a strong agreement among experts on the relevance of gamified tasks for motor skill enhancement, engagement, and user adaptability. However, challenges such as balancing task complexity and maintaining therapeutic focus emerged as critical areas for refinement.

Conclusion: The study highlights the importance of incorporating domain-specific expertise during the design and validation phases to ensure the interventions meet therapeutic objectives effectively. By establishing robust content validity, this research contributes to the optimization and credibility of VR-based rehabilitation programs for children with CP. The findings underscore the significance of structured validation methodologies in the development of innovative healthcare solutions, fostering their integration into clinical practice and enhancing therapeutic outcomes for paediatric populations.

Keywords: Content validity, Virtual reality, Rehabilitation, Cerebral palsy, Paediatric therapy, Content validity ratio, Content validity index.

Introduction

The integration of virtual reality (VR) into rehabilitation programs represents a transformative approach for enhancing therapeutic outcomes, particularly for children with cerebral palsy (CP)[1], [2]. Cerebral palsy, a neurodevelopmental condition affecting motor function and coordination, requires innovative and engaging rehabilitation strategies to improve functional outcomes and quality of life[3], [4], [5]. VR-based interventions offer interactive, gamified environments that motivate children while providing targeted therapeutic exercises. However, for these interventions to be effective and widely adopted, their content validity—defined as the degree to which the elements of an intervention are relevant, representative, and aligned with therapeutic goals—must be rigorously evaluated.

Content validity is critical in establishing the effectiveness and appropriateness of instruments or interventions, particularly in healthcare settings where measurable improvements are paramount[6], [7], [8]. This validation process involves expert assessment to ensure that the intervention content aligns with the targeted rehabilitative needs of children with CP. Furthermore, it addresses potential threats, such as content underrepresentation or the inclusion of irrelevant elements, which could compromise the therapeutic utility of the intervention.

While the benefits of VR-based rehabilitation are well-documented, the evaluation of its content validity remains an evolving area of study. This research aims to systematically assess the content validity of VR-based rehabilitation tools for children with CP, leveraging established methodologies such as expert panel evaluations and content validity indices (CVR and CVI). By ensuring the interventions are both relevant and representative of the targeted therapeutic objectives, this study seeks to contribute to the optimization of VR applications in paediatric rehabilitation.

Background:

A collection of long-term neurodevelopmental conditions known as cerebral palsy (CP) are caused by non-progressive abnormalities in the developing brain and impact posture and movement [9]. Affecting approximately 1 in 500 children world-wide. The primary cause of childhood motor dysfunction, cerebral palsy (CP), frequently coexists with sensory, cognitive, and communication challenges. With treatments aimed at boosting motor control, balance, strength, and coordination, rehabilitation is essential to improve motor function and quality of life for kids with cerebral palsy [10], [11], [12]. However, traditional rehabilitation programs may struggle to sustain engagement, especially in children, due to their repetitive and physically demanding nature.

With its immersive and engaging surroundings that encourage users through gamification, virtual reality (VR) has become a game-changing tool in rehabilitation [13], [14]. For children with CP, VR-based rehabilitation holds the potential to provide customizable, task-oriented exercises that align with therapeutic goals while maintaining high levels of engagement. The dynamic feedback and progress monitoring capabilities inherent in VR make it a unique and promising modality in paediatric therapy[15], [16], [17], [18], [19], [20]. Furthermore, VR allows clinicians to create controlled environments tailored to the specific needs of individual patients, facilitating the practice of functional activities in ways that are not feasible in traditional settings.

Despite its potential, the successful implementation of VR in clinical practice requires rigorous validation of its therapeutic content. Content validity, which assesses whether the elements of an intervention are representative, relevant, and aligned with the intended therapeutic objectives, is critical for ensuring the effectiveness and clinical utility of VR-based rehabilitation. Insufficient validation may lead to interventions that fail to address critical therapeutic needs or introduce irrelevant elements, thereby undermining clinical outcomes.

This study seeks to address the gap by evaluating the content validity of VR-based rehabilitation interventions for children with CP, providing a foundation for their optimization and broader adoption in clinical settings.

Materials and Methods

This study design is a part of VR based rehabilitation method for children with Cerebral Palsy. The data in the initial phase of the study was collected with semi structured interviews with 9 children with CP, four family members, two orthopaedic surgeon, three paediatric physiotherapist and one biomechanics expert. During content validity stages, qualitative and quantitative viewpoints of seven experts were collected. Content validity is crucial in the development of instruments used in fields such as healthcare, education, and social sciences, where constructs like patient satisfaction, cognitive abilities, or quality of life are abstract and cannot be directly observed. Without sufficient content validity, the results generated by the instrument may not accurately reflect the true characteristics or outcomes being measured, leading to invalid conclusions.

A test's or measuring tool's ability to evaluate the complete content it is meant to measure is known as content validity. The steps involved in establishing content validity are development stage and judgemental stage in overall[21], [22], [23], [24], [25].

Ethical considerations such as approval of ethical committee of Vishwakarma University was taken in prior. Content validity for VR based rehabilitation method for children with CP was done in two stages.

Stage 1: Development Stage

Development stage focuses on defining the construct and creating the VR game environment in the Head Mounted Device hardware. Two steps were conducted to complete development stage of content validity. First step domain definition- Here we clearly define the concept to be measured, both theoretically and operationally. For domain definition thorough literature review, expert input, and contextual analysis to identify the dimensions and elements of the construct were conducted. In Item Generation, researcher develop items that reflect the construct's domains and dimensions based on the gain knowledge. Items are clear, specific, and relevant to the target population and second step is Instrument Construction in which after assemble the items into a cohesive tool, organizing them into relevant categories or dimensions was done.

Stage 2: Judgemental Stage

The judgmental stage of content validity focuses on the systematic evaluation of test items or content by experts in the field of Paediatric rehabilitation. The goal of this stage is to ensure that the content adequately represents the domain it aims to measure. This process involves a panel of paediatric rehabilitation experts who assess the relevance, clarity, and representativeness of each item. Out of 40 items,38 items were selected and modified with minor change by discussion and analysis process. Content validity process identified seven dimensions includes Satisfaction (Five items), Motivation in participation (Eight items), Functional Ability/Task Difficulty (Nine items) Joy in playing VR based rehab game (Eight items), Memory Load (Two items), Frustrations (Four Items), Retention in participation (2 items). Experts rate each item on a Likert scale, from 1 (not relevant) to 4 (highly relevant). The ratings are collected and analysed quantitatively to calculate indices such as the Content Validity Ratio (CVR) and the Content Validity Index (CVI).

Content Validity Ratio: To calculate the Content Validity Ratio (CVR) for each question, we use the formula:

$$CVR = \frac{n_e - (N/2)}{N/2}$$

[21], [24]

Where:

- n_e = Number of experts rating the item as "essential" (1 in this case)
- N = Total number of experts.

For Items 1–21, 23–37, Content Validity Ratio is

$$CVR = \frac{(7 - 3.5)}{3.5} = \frac{3.5}{3.5} = 1.00$$

For Item 22 (Only 6 experts rated as "1"), Content Validity Ratio is

$$CVR = \frac{(6 - 3.5)}{3.5} = \frac{2.5}{3.5} = 0.71$$

For Item 38 (Only 6 experts rated as "1"), Content Validity Ratio is

$$CVR = \frac{(6 - 3.5)}{3.5} = \frac{2.5}{3.5} = 0.71$$

Most items have a high CVR of 1.00. Item 22 and 38 have a CVR of 0.71, which may need revision if the threshold is **≥0.78**. After revisiting item, discussion and analysis with the experts, Item 22 and 38 item was modified and updated.

The CVI for the instrument is the average of the CVRs for all items:

Formula for Item-Level CVI (I-CVI):

$$I-CVI = \frac{\text{Number of experts who rated the item as "1"}}{\text{Total number of experts}}$$ [24]

I-CVI for each itemS

All items have been rated "1" by all experts except for Item 22 and Item 38**.**

For Items 1–21, 23–37**:**

$$I-CVI = \frac{7}{7} = 1.00$$

For **Item 22** (Expert 3 rated "0"):

$$I-CVI = \frac{6}{7} = 0.86$$

For **Item 38** (Expert 3 rated "0"):

$$I-CVI = \frac{6}{7} = 0.86$$

Scale-Level CVI (S-CVI)

There are Two methods to compute **S-CVI**:

1. S-CVI/Ave (Average of I-CVI scores):

$$S-CVI/Ave = \frac{\sum I-CVI}{\text{Total Items}}$$

$$S-CVI/Ave = \frac{36(1.00)+2(0.86)}{38}$$

$$S-CVI/Ave = \frac{36+1.72}{38} = \frac{37.72}{38} = 0.99$$

2. S-CVI/UA (Universal Agreement):

$$S-CVI/UA = \frac{\text{Number of items with I-CVI} \geq 0.78}{\text{Total Items}}$$

$$S-CVI/UA = \frac{38}{38} = 1.00$$

The results showed high Item-Level CVI (I-CVI) and Scale-Level CVI (S-CVI) values, indicating that the majority of experts agreed on the relevance of the items. The S-CVI scores surpassed the threshold of 0.78, reflecting strong agreement and overall content relevance. This reinforces that the instrument adequately captures the domain it is intended to measure.

Modified Kappa Statistics

$$\kappa = \frac{I - CVI - P_e}{1 - P_e}$$

[24]

P_e = Probability of chance agreement

$$P_e = \frac{\text{Combination of A experts choosing 1 out of N}}{2^N}$$

For **Item 22 and 38** (since I-CVI = 0.86 and **6 out of 7 experts** rated "1"):

$$P_e = \frac{(7!/(6!(7-6)!))}{2^7}$$

$$P_e = \frac{7}{128} = 0.0547$$

Now,

$$\kappa = \frac{0.86 - 0.0547}{1 - 0.0547} = \frac{0.8053}{0.9453} = 0.85$$

Since κ = 0.85, the agreement beyond chance is excellent for Item 22 and 38 and other items have κ = 1.00, indicating perfect agreement. This provides further evidence of the reliability of the expert ratings and minimizes the risk of bias or random agreement. Content Validity Ratio, Content Validity Index and Kappa Statistics shown in the Table 1.

TABLE 1: Question numbers, Experts judgement, expert essential rating, Content Validity Ratio, Content Validity Index and Kappa Values.

Q. No	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Ne	CVR	I-CVI	Kappa
1	1	1	1	1	1	1	1	7	1.00	1.00	1.00
2	1	1	1	1	1	1	1	7	1.00	1.00	1.00
3	1	1	1	1	1	1	1	7	1.00	1.00	1.00
4	1	1	1	1	1	1	1	7	1.00	1.00	1.00
5	1	1	1	1	1	1	1	7	1.00	1.00	1.00
6	1	1	1	1	1	1	1	7	1.00	1.00	1.00
7	1	1	1	1	1	1	1	7	1.00	1.00	1.00
8	1	1	1	1	1	1	1	7	1.00	1.00	1.00
9	1	1	1	1	1	1	1	7	1.00	1.00	1.00
10	1	1	1	1	1	1	1	7	1.00	1.00	1.00
11	1	1	1	1	1	1	1	7	1.00	1.00	1.00
12	1	1	1	1	1	1	1	7	1.00	1.00	1.00
13	1	1	1	1	1	1	1	7	1.00	1.00	1.00
14	1	1	1	1	1	1	1	7	1.00	1.00	1.00
15	1	1	1	1	1	1	1	7	1.00	1.00	1.00

16	1	1	1	1	1	1	1	7	1.00	1.00	1.00
17	1	1	1	1	1	1	1	7	1.00	1.00	1.00
18	1	1	1	1	1	1	1	7	1.00	1.00	1.00
19	1	1	1	1	1	1	1	7	1.00	1.00	1.00
20	1	1	1	1	1	1	1	7	1.00	1.00	1.00
21	1	1	1	1	1	1	1	7	1.00	1.00	1.00
22	1	1	0	1	1	1	1	6	0.71	0.86	0.86
23	1	1	1	1	1	1	1	7	1.00	1.00	1.00
24	1	1	1	1	1	1	1	7	1.00	1.00	1.00
25	1	1	1	1	1	1	1	7	1.00	1.00	1.00
26	1	1	1	1	1	1	1	7	1.00	1.00	1.00
27	1	1	1	1	1	1	1	7	1.00	1.00	1.00
28	1	1	1	1	1	1	1	7	1.00	1.00	1.00
29	1	1	1	1	1	1	1	7	1.00	1.00	1.00
30	1	1	1	1	1	1	1	7	1.00	1.00	1.00
31	1	1	1	1	1	1	1	7	1.00	1.00	1.00
32	1	1	1	1	1	1	1	7	1.00	1.00	1.00
33	1	1	1	1	1	1	1	7	1.00	1.00	1.00
34	1	1	1	1	1	1	1	7	1.00	1.00	1.00
35	1	1	1	1	1	1	1	7	1.00	1.00	1.00
36	1	1	1	1	1	1	1	7	1.00	1.00	1.00
37	1	1	1	1	1	1	1	7	1.00	1.00	1.00
38	1	1	0	1	1	1	1	6	0.71	0.86	0.86

The findings suggest that the instrument is well-aligned with the theoretical construct and meets high standards of content validity. The high agreement across multiple validity measures ensures that the instrument is robust and suitable for its intended use. These results also highlight the importance of involving diverse and qualified subject matter experts in the judgmental stage to enhance the comprehensiveness and accuracy of the instrument.

Discussion:

The robust content validity established in this study underscores the importance of expert judgment and systematic evaluation in the instrument development process. Following predetermined standards and employing quantitative measures like CVR, CVI, and kappa statistics, the instrument exhibits a high degree of relevance and clarity, making it a trustworthy instrument for evaluating the target construct.

Acknowledgement:

The researchers appreciate all the expert panel members, Children with Cerebral Palsy, their Parents for their time and inputs. The study is ethically approved by Vishwakarma University's local approval committee.

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