

## THE SCHOOL TRANSITIONING EFFECTS OF VIRTUAL REALITY-BASED VIDEO MODELLING INTERVENTION ON AUTISTIC CHILDREN

Yi Ling Ang<sup>1</sup>, Sima Ahmadpour<sup>2\*</sup>, Hock Guan Goh<sup>3</sup>, Chen Kang Lee<sup>4</sup>, Kai Shuen Pheh<sup>5</sup>

<sup>1,2,3</sup>Faculty of Information and Communication Technology; Universiti Tunku Abdul Rahman;  
Jalan Universiti, 31900 Kampar, Perak, Malaysia

<sup>4</sup>Faculty of Engineering and Science; Universiti Tunku Abdul Rahman;  
Jalan Sungai Long, Bandar Sungai Long, 43000 Kajang, Selangor, Malaysia

<sup>4</sup>Faculty of Arts and Social Science; Universiti Tunku Abdul Rahman;  
Jalan Universiti, 31900 Kampar, Perak, Malaysia

<sup>5</sup>Hospital Universiti Tunku Abdul Rahman, Jalan Hospital UTAR,  
31900 Kampar, Perak.

Emails: angyl@utar.edu.my<sup>1</sup>, simaahmad@utar.edu.my<sup>2\*</sup> (Corresponding author), gohhg@utar.edu.my<sup>3</sup>,  
lckang@utar.edu.my<sup>4</sup>, phehkaishuen@gmail.com<sup>5</sup>

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### ABSTRACT

*Autistic children frequently experience significant difficulties during school transitions, including challenges with social communication, behavioral regulation, and adapting to unfamiliar environments. Although both Virtual Reality (VR) and Video Modelling (VM) have been independently investigated as effective interventions for Autism Spectrum Disorder (ASD), their combined application specifically targeting school transition behaviors remains underexplored in the literature. This pilot pre-post feasibility study examined the effects of a customizable Virtual Reality Video Modelling (VRVM) intervention on school-transition-related behavioral and social outcomes in autistic children. Seven autistic children (aged 5–7 years) participated in weekly VRVM training sessions conducted from January to March 2024, prior to school enrolment. The VRVM application, delivered via a Google Cardboard head-mounted display (HMD) on an Android device, presented three point-of-view video modelling storylines depicting school-related social scenarios. Pre- and post-intervention assessments were conducted using the Social Responsiveness Scale - Second Edition (SRS-2) and the Behavior Assessment System for Children - Third Edition (BASC-3). Effect sizes were quantified using Cohen's *d*. Pre- and post-intervention scores showed improvements across multiple scales. The Cohen's *d* values were  $d = 1.247$  for hyperactivity (large effect),  $d = 0.739$  for Behavioral Symptoms Index from BASC-3 (medium-to-large effect), and  $d = 0.546$  for social awareness from SRS-2 (medium effect). However, effect sizes derived from small samples may be upwardly biased and should be interpreted with caution. Conclusions: These preliminary findings suggest that VRVM is a feasible and promising augmentative approach for supporting school transition in autistic children. Future controlled research with larger samples is warranted to confirm these effects.*

**Keywords:** *Virtual Reality Intervention; Video Modelling; Autism Spectrum Disorder; School Transition; Social Skills Training; Assistive Technology.*

### 1.0 INTRODUCTION

Autism Spectrum Disorder (ASD) is a common childhood neurodevelopmental disorder. The American Psychiatric Association (2022) characterizes ASD by significant deficits in social communication and social interaction abilities, as well as by the presence of restricted and repetitive behaviors. Autistic children often face significant challenges when transitioning to school owing to cognitive and behavioral difficulties [1]. They also have difficulty expressing their feelings [2].

School transition is one of the most demanding periods for autistic children [3], [4]. Entering a new school environment requires adapting to unfamiliar people, routines, and social expectations tasks that present considerable difficulty for children with ASD [5].

Inadequate preparation for these experiences can result in heightened anxiety, behavioral disruptions, and social withdrawal, negatively affecting the child's long-term educational participation. There is therefore a clear need for accessible, pre-school interventions that help autistic children familiarize themselves with school-related social scenarios before they occur.

Several interventions have been found to improve the social communication skills of autistic children in daily life [6]. With advances in technology, VR has been considered an effective tool for helping autistic children learn appropriate behavior in different settings [7], [8]. Virtual reality-based video modelling has proved to be highly usable for autistic individuals as an adjunct intervention for improving social skills [9], [10]. Virtual reality-based video modelling interventions can be used as augmentative interventions that prolong the effect of the main therapy [11], [12]. Research showed that both virtual reality (VR) and video modelling (VM) interventions successfully facilitate the learning of autistic individuals. However, the combination of VR and VM has not been sufficiently explored, although such a combination may prove highly effective [5], [13]. Therefore, the effectiveness of implementing VM within VR is a central concern of this research.

Despite growing interest in technology-based interventions for ASD, a critical gap exists in the literature. To the best of the authors' knowledge, no prior study has investigated the combined use of VR and point-of-view (POV) video modelling as an augmentative intervention specifically targeting school transition behaviors in autistic children. The most comprehensive systematic review of POV video modelling for young autistic learners to date [14] reviewed 13 peer-reviewed POV-VM intervention studies and confirmed that all used standard 2D screen-based video delivery, and none incorporated immersive VR technology. Moreover, none of the 13 studies addressed school transition as a target domain; skills covered were play, daily living, social initiations, academic readiness, and behaviors raising concerns. While Fitzgerald et al. [13] compared VR and VM as separate interventions, their combined delivery via a first-person immersive format remains uninvestigated. This study directly addresses this gap by developing and evaluating a customizable VRVM intervention the first to deliver POV video modelling via an immersive VR platform (Google Cardboard HMD) and the first POV-VM intervention specifically designed for the school transition context.

Nevertheless, different needs lead to different designs of VR-based interventions [15], [16], [17]. Personalizing a VR-based intervention requires a lengthy process of requirements gathering and intervention development. Real-time personalization according to participants' reactions was carried out by an expert which made in-house intervention training inefficient [18]. Therefore, a time-consuming data collection and development processes, along with the need for experts during intervention training, remain the key challenges in this area.

Furthermore, the use of a head-mounted display (HMD) during the training is the critical concern for home-based training owing to its high cost. To provide an immersive virtual world experience, an HMD was required. Therefore, Google Cardboard is a good choice as it balances between usability and immersion and is affordable [9].

VR provides a safe environment for autistic children to explore the virtual world, learn how to perform tasks, and interact with people in 3D simulation experiences [18], [19]. In a realistic virtual school environment, autistic children can prepare themselves for adapting to a new environment in the future. Knowing that the environment is virtual allows autistic children to explore it without fear. Consequently, the less hazardous virtual environment is less hazardous, making it safer to conduct potentially risky training activities [18], [20].

VM is a technique that uses video to demonstrate target behaviors that could be imitated by watching them. Research has shown that VM effectively assisted autistic children in imitating targeted behaviors, such as making eye contact [21], and playing and interacting with peers [22], [23]. Several forms of VM are available, including video self-modelling, and point-of-view VM. In this research, point-of-view (POV) VM was implemented because it is designed from the perspective of autistic children and presented from their viewpoint, which is interested to make it more effective than the other forms of VM [24].

Compared with 2D-VM, VR-based video modeling enhances participants' sense of presence within the virtual environment [13]. By wearing an HMD, participants could immerse themselves in the virtual school environment and engage with the VM. Fully immersive VR offers a flexible experience where head and body rotation are allowed with motion tracking, and the VR view is updated accordingly [25], [26]. In contrast, rotation was restricted in this research to minimize potential distractions and keep the focus on the storyline of the video [24]. A customization feature was provided for parents of autistic children to better tailor the program according to their children's needs [27]. Technology-based interventions enhance the efficiency of the customization process, for example by allowing attractive pictures to be inserted to enhance engagement [28], [29]. Nevertheless, a simple customization process that can be completed without technical background knowledge may be preferred by parents [30]. Customization according to autistic children's preferences improve the training outcomes by enhancing their engagement [27].

This paper presents the motivation for designing an augmentative customizable virtual reality video modelling (VRVM) intervention to assist autistic children in transitioning to school. The design of the intervention and the procedure of the intervention training for autistic children are also presented in this paper. The VRVM is delivered via an Android device with Google Cardboard to achieve an immersive VR experience.

The paper is organized as follows: Section 2 describes the research materials and methods, including the VRVM intervention, the assessment tools, the training design, and participants. Section 3 presents the result and Section

4 discusses them. Finally, Section 5 presents the conclusions, limitations, and recommendations for future research.

## 2.0 MATERIALS AND METHODS

### 2.1 Virtual Reality Video Modelling (VRVM) Intervention Application

After observing the school attended by students with special needs, the requirements of the intervention were drafted to meet their needs in the school environment, the possible situations such as conversations with teachers and classmates, were designed. An augmentative customizable VRVM intervention was developed as an Android application to present three different stories in a school setting, aimed at assisting autistic children in familiarizing themselves with a new school environment. By presenting the videos from a first-person point of view, autistic children could immerse themselves in the school environment and the storyline. Considering the cost of VR headset hardware, the VRVM utilized the Google Cardboard HMD, which provides an affordable and immersive experience. By installing the VRVM application (APK file) on an Android device, parents can play the videos and start training their autistic children anywhere, and at any time. The VRVM application was developed in Unity, and it provides three storylines in the VM format as follows:

1. Going to a new school
2. Making new friends in class
3. Behaving appropriately during lessons.

In the first VM, children are shown the new school they will soon attend to help them prepare and are introduced to virtual teachers and classmates as shown in Fig. 1. A virtual avatar greeted the child, modelling on appropriate way of greeting others.

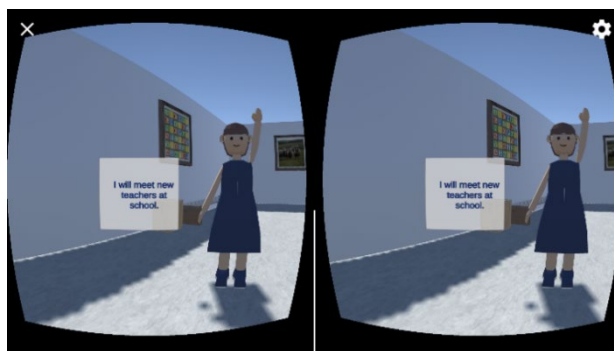


Fig. 1: The scene captured in the first video modelling.

The second VM shows a few short conversations with classmates to familiarize children with how to communicate method with peers (Fig. 2). The scene depicts a first-person perspective in which the child's avatar engages in a conversation with a classmate about borrowing stationery a common social initiation scenario in a classroom setting. The figure illustrates the POV framing of the interaction, with the classmate's avatar visible in front of the child and a speech dialogue shown on screen.

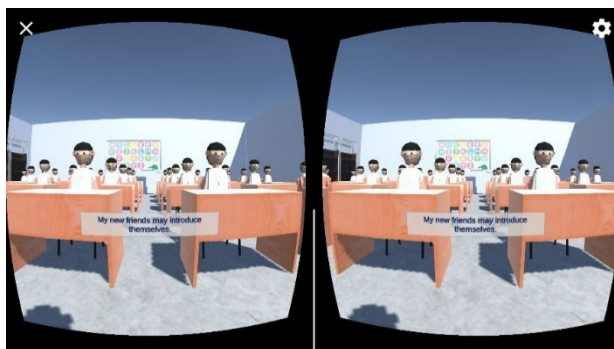


Fig. 2: The scene captured in the second video modelling.

Lastly, the third VM depicts appropriate classroom behaviors, such as focusing on the teacher during lessons to discourage disruptive behavior, as shown in Fig. 3.

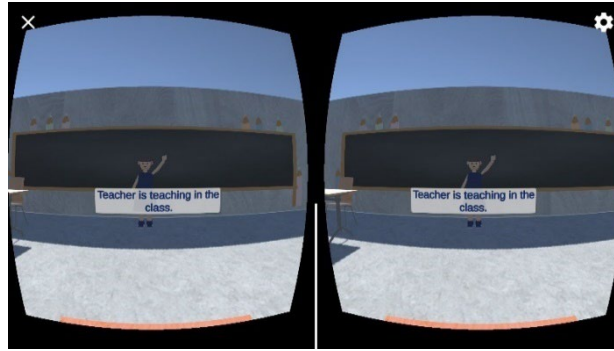


Fig. 3: The scene captured in the third video modelling.

The VRVM application offers several customization features for parents:

1. Upload a photograph of the actual school, as shown in Fig. 4 (a), the image is then placed in the story.
2. Input the autistic child's name, which is used in the storyline.
3. Adjust the wallpaper color of the classroom.
4. Modify the design of the tables and chairs in the classroom as shown in Fig. 4(b) and Fig. 4(c).
5. Select the preferred language.



Fig. (a)

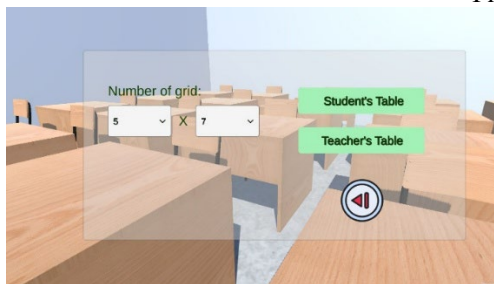


Fig. (b)

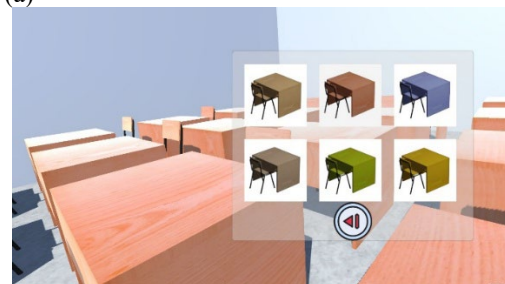


Fig. (c)

Fig. 4: Composite overview of the VRVM customization interface.

(a) School image upload panel parents upload the child's actual school photograph to replace the default virtual background. (b) Customization feature: Adjust the number of tables. (c) Customization feature: Select the design of the table.

The content and language of the intervention were reviewed by psychology experts to ensure that the language and terms used were appropriate and easily understood by autistic children. The experts' suggestions were considered, and amendments were made accordingly. Before starting the intervention training, parents were taught how to use the features provided so that they could customize the virtual school environment accordingly. After customization, the Android device was placed in the Google Cardboard HMD, and the participant wore the HMD to experience the VM.

## 2.2 Measures

Three assessment tools were used involved in the intervention training; the Childhood Autism Rating Scale - Second Edition (CARS-2) was used to collect participants' demographic data, the Social Responsiveness Scale -

Second Edition (SRS-2) and the Behavior Assessment System for Children - Third Edition (BASC-3) were used to compare the pre- and post-intervention results.

### **2.2.1 Social Responsiveness Scale, Second Edition (SRS-2)**

The Social Responsiveness Scale - Second Edition (SRS-2) is a standardized assessment tool designed to measure the severity of social impairment associated with Autism Spectrum Disorder [31]. It is widely used in both clinical and research settings due to its robust psychometric properties and comprehensive evaluation of social behavior [32]. The SRS-2 is a 65-item questionnaire completed by a parent, teacher, or other adult who has regular interaction with the child. The items are rated on a four-point Likert scale ranging from "Not True" to "Almost Always True." The scale assesses five key domains: Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests and Repetitive Behavior. Scores from these domains are combined to provide a Total Score, which indicates the overall severity of social impairment. The SRS-2 is valuable in identifying subtle social difficulties and guiding intervention strategies, making it an essential tool for evaluating the impact of interventions like the VRVM used in this study.

### **2.2.2 Behavior Assessment System for Children, Third Edition (BASC-3)**

The Behavior Assessment System for Children - Third Edition (BASC-3) is used to measure the behavior and perceptions of individuals aged 2 to 25 years via a multimethod and multidimensional system [33]. The BASC-3 rating scales comprise of 105 to 165 items and are completed by a parent, teacher, or other adult who has regular interaction with the child. The scale assesses in this assessment tool: Hyperactivity, Anxiety, Withdrawal, and Social Skills, among others. The score on each scale indicates the severity of the corresponding behavior. Therefore, the effect of the VRVM could be examined by comparing the scale scores before and after the intervention training.

### **2.2.3 Childhood Autism Rating Scale, Second Edition (CARS-2)**

The Childhood Autism Rating Scale - Second Edition (CARS-2) was used during in the participant demographic data collection stage. It is a 15-item clinician-rated scale that objectively quantifies children's behavior based on direct observation and parent report. It has been widely used to diagnose autism worldwide [34]. Each is rated on a scale of 1 to 4, with 1 indicating behavior within normal limits for that age and 4 indicating severely abnormal behavior for that age, midpoints are used when the behavior falls between the two categories.

## **2.3 Intervention Training Design**

The intervention training was conducted from January to March 2024 in weekly sessions seperated. The collection of all personal data during the intervention training was approved by the Universiti Tunku Abdul Rahman, Scientific and Ethical Review Committee with approval number U/SERC/279/2023. The intervention was conducted in the following phases:

**Pre-intervention Phase:** During the first visit, parents of autistic children were required to complete the pre-intervention assessment by using the assessment tools: CARS-2, SRS-2, and BASC-3.

**Intervention Training Phase:** The training sessions were conducted once a week before school term began in March 2024. Each session lasted approximately 1 hour and was conducted individually. Autistic children were required to wear the Google Cardboard HMD to experience the VM.

**Post-intervention Phase:** The post-intervention assessment was carried out one week after the children started school by using the SRS-2 and BASC-3.

**Evaluation:** After collecting the pre- and post-intervention assessment results, the effectiveness of the VRVM was evaluated by comparing and interpreting the results.

Each participant attended a total of 8 weekly training sessions over the two-month pre-school period. In each session, participants viewed all three VR storylines sequentially. Each individual VR story lasted approximately 5–7 minutes, resulting in approximately 20–25 minutes of total VR exposure per session, with the remainder of the 1-hour session used for familiarization, equipment setup, and parental briefing. Prompts during VR viewing sessions were provided by the researcher, with parents present in the room as passive observers. Session notes were recorded by the researcher after each session. All seven participants who entered the training phase completed all 8 sessions, representing 100% adherence. No participant refused to participate and no cases of cybersickness were reported during or after any session. Two participants (P3 and P6) initially showed mild hesitation about wearing the HMD during the first session. This was managed by allowing the child to first handle the device

without wearing it, briefly viewing the screen without the headband, and then transitioning gradually to full HMD use. Both participants wore the HMD comfortably from the second session onward.

The three VR storylines (going to school, making friends, and classroom behavior) were selected based on a structured needs assessment conducted at the partnering special needs school prior to development. School staff identified these three domains as the most frequently reported school transition challenges among the existing ASD student population. The behaviors modelled in each story (greeting teachers, borrowing stationery, and attending quietly to a lesson) were selected with input from a trainee clinical psychologist and reviewed for appropriateness for the age group and autism severity levels of the target participants.

## 2.4 Participants

A total of seven participants who fulfilled the requirements took part in the intervention as shown in Table 1. Initially, there were 11 participants were recruited. However, three had have a low IQ (Full-Scale IQ<85) and were unable to understand the contents of the VRVM and one was unable to attend any of the available time slots, leaving seven participants. The participants' requirement was based on their age, autism severity level where CARS-2 T-score greater than 30.0 indicates autism, and willingness to join the training. A sample of seven is consistent with pilot feasibility studies in the VRVM and POV video modelling literature, which typically involve 5–12 participants [13], [35]. The final sample size was further constrained by the strict eligibility criteria, the limited pool of eligible children at the partnering special needs school, and the training window between January and March 2024, which had to conclude before school opened in March. This pilot study was not designed or powered to produce definitive statistical conclusions, but rather to evaluate feasibility and provide preliminary effect size estimates for use in future power calculations.

Table 1: Participant Demographics

| Participants | Age | Gender | CARS-2 T-Score |
|--------------|-----|--------|----------------|
| P1           | 5   | Female | 33; mild       |
| P2           | 7   | Female | 29.5; mild     |
| P3           | 5   | Male   | 38.5; severe   |
| P4           | 6   | Male   | 29.5; mild     |
| P5           | 7   | Female | 36.5; mild     |
| P6           | 7   | Male   | 32.0; mild     |
| P7           | 6   | Male   | 30.5; mild     |

## 3.0 RESULTS

Tables 2 and 3 show the mean scores and standard deviations of the pre-intervention results, and post-intervention results for each scale of the BASC-3 and SRS-2. The effect size for each scale of BASC-3 and SRS-2 was calculated using Cohen's d. Durbin-Conover non-parametric pairwise comparison tests were conducted for all scales [36]. Statistically significant pre-post differences ( $p < .05$ ) were found on the following BASC-3 scales: Anxiety ( $t = 3.074$ ,  $df = 6$ ,  $p = .022$ ,  $d = 0.568$  [95% CI: 0.000, 1.664]), Somatization ( $t = 3.074$ ,  $p = .022$ ,  $d = 0.426$  [0.000, 1.501]), Internalizing Problems ( $t = 3.074$ ,  $p = .022$ ,  $d = 0.610$  [0.000, 1.713]), Attention Problem ( $t = 7.483$ ,  $p < .001$ ,  $d = 0.327$  [0.000, 1.391]), Withdrawal ( $t = 6.614$ ,  $p < .001$ ,  $d = 0.508$  [0.000, 1.594]), Social Skills ( $t = 15.875$ ,  $p < .001$ ,  $d = 0.581$  [0.000, 1.680]), and Activities of Daily Living ( $t = 3.074$ ,  $p = .022$ ,  $d = 0.484$  [0.000, 1.566]). For the SRS-2, significant differences were found for Total Score ( $t = 5.084$ ,  $p = .002$ ,  $d = 0.132$  [0.000, 1.182]), Social Awareness ( $t = 3.813$ ,  $p = .009$ ,  $d = 0.229$  [0.000, 1.284]), and Social Communication and Interaction ( $t = 3.074$ ,  $p = .022$ ,  $d = 0.068$  [0.000, 1.117]). Tables 6 and 7 below present the full Durbin-Conover results with 95% confidence intervals [37]. It is important to note that Cohen's d values, while informative, are susceptible to inflation in small samples ( $n = 7$ ); the wide 95% confidence intervals reported reflect this instability and should be interpreted with appropriate caution.

Scales with an effect size (Cohen's d value) greater than 0.2 are considered practically significant with a d value greater than 0.5 having a medium effect, and greater than 0.8 indicating a large effect [38], [39]. Cohen's effect size is a standardized measure of the magnitude of an effect, and is not directly affected by sample size, making it suitable for this research given the small sample size used in the intervention training [40].

The effect sizes for the BASC-3 scales presented in Table 2 indicate that the VRVM intervention is effective in reducing autistic children's hyperactivity issues, such as disrupting others while they do schoolwork. The medium effect sizes for the scales of anxiety and atypicality indicate that the VRVM intervention assisted autistic

children in reducing feelings of fear, and nervousness. Moreover, the medium effect size for the SRS-2 Social Awareness scale ( $d = 0.546$ ) indicates that the VRVM intervention helped the children pay attention to others' speech.

Table 2: Pre- and Post-Intervention Results in Mean, Standard Deviation, and the Calculated Cohen's  $d$  Value for BASC-3

| BASC-3 Scales             | Pre-Intervention |      | Post-Intervention |      | Cohen's $d$ for Pre- and Post-Intervention |
|---------------------------|------------------|------|-------------------|------|--------------------------------------------|
|                           | M                | SD   | M                 | SD   |                                            |
| Hyperactivity             | 57.9             | 6.07 | 52.3              | 1.86 | 1.247                                      |
| Externalizing Problems    | 52.6             | 5.62 | 49.3              | 6.47 | 0.545                                      |
| Anxiety                   | 47               | 2.52 | 43.3              | 9.33 | 0.541                                      |
| Atypicality               | 67.1             | 11.9 | 60.5              | 9.54 | 0.612                                      |
| Behavioral Symptoms Index | 60.4             | 4.96 | 56.7              | 5.05 | 0.739                                      |
| Social Skills             | 30.6             | 6.73 | 34.3              | 8.14 | 0.495                                      |

Table 3: Pre- and Post-Intervention Results in Mean, Standard Deviation, and the Calculated Cohen's  $d$  Value for SRS-2

| SRS-2 Scales      | Pre-Intervention |      | Post-Intervention |      | Cohen's $d$ for Pre- and Post-Intervention |
|-------------------|------------------|------|-------------------|------|--------------------------------------------|
|                   | M                | SD   | M                 | SD   |                                            |
| Social Awareness  | 74.3             | 6.75 | 69.7              | 9.81 | 0.546                                      |
| Social Motivation | 64.1             | 13.3 | 58.3              | 9.99 | 0.493                                      |

Table 4: BASC-3 Pre- and Post-Intervention Results for All Participants

| Participants               | P1  |      | P2  |      | P3  |      | P4  |      | P5  |      | P6  |      | P7  |      |
|----------------------------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|
|                            | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Hyperactivity              | 51  | 55   | 66  | 54   | 58  | 51   | 63  | 72   | 59  | 50   | 49  | 52   | 59  | 52   |
| Aggression                 | 38  | 48   | 59  | 45   | 38  | 38   | 54  | 61   | 48  | 42   | 48  | 67   | 56  | 48   |
| Conduct Problems           | -   | -    | 45  | 38   | -   | -    | -   | -    | 45  | 43   | 56  | 61   | 58  | 48   |
| Externalizing Problems     | 44  | 52   | 57  | 45   | 48  | 44   | 59  | 68   | 51  | 45   | 51  | 61   | 58  | 49   |
| Anxiety                    | 44  | 40   | 47  | 38   | 47  | 38   | 51  | 44   | 44  | 34   | 47  | 53   | 49  | 57   |
| Depression                 | 49  | 47   | 43  | 48   | 51  | 51   | 58  | 43   | 54  | 41   | 48  | 56   | 45  | 48   |
| Somatization               | 49  | 42   | 53  | 45   | 56  | 49   | 49  | 42   | 43  | 45   | 63  | 71   | 63  | 55   |
| Internalizing Problems     | 47  | 41   | 47  | 42   | 52  | 45   | 53  | 41   | 46  | 38   | 53  | 62   | 53  | 54   |
| Attention Problem          | 70  | 70   | 68  | 70   | 58  | 58   | 74  | 79   | 59  | 63   | 54  | 54   | 61  | 68   |
| Atypicality                | 76  | 71   | 70  | 58   | 48  | 46   | 69  | 85   | 85  | 54   | 62  | 68   | 60  | 66   |
| Withdrawal                 | 74  | 59   | 51  | 48   | 61  | 58   | 47  | 56   | 68  | 58   | 58  | 48   | 76  | 73   |
| Behavioral Symptoms Index  | 62  | 61   | 62  | 55   | 53  | 50   | 64  | 71   | 66  | 52   | 54  | 60   | 62  | 62   |
| Adaptability               | 38  | 34   | 39  | 49   | 40  | 36   | 40  | 48   | 41  | 37   | 39  | 43   | 35  | 37   |
| Social Skills              | 25  | 28   | 40  | 45   | 25  | 32   | 35  | 37   | 23  | 23   | 37  | 39   | 29  | 39   |
| Leadership                 | -   | -    | 33  | 36   | -   | -    | -   | -    | 36  | 33   | 40  | 42   | 29  | 33   |
| Functional Communication   | 33  | 28   | 36  | 33   | 23  | 33   | 36  | 33   | 28  | 34   | 40  | 43   | 33  | 36   |
| Activities of Daily Living | 34  | 42   | 42  | 44   | 29  | 22   | 57  | 52   | 37  | 42   | 35  | 48   | 24  | 42   |
| Adaptive Skills            | 28  | 29   | 36  | 40   | 24  | 26   | 40  | 41   | 31  | 32   | 37  | 42   | 27  | 36   |

The intervention training resulted in improvements across various BASC-3 scales for the participants, as shown in Table 4. For the scales from Hyperactivity to the Behavioral Symptoms Index, higher scores indicate more severe problems, conversely for the remaining scales, lower scores indicate more severe problems. Five of seven participants, all except P4 improved on the Withdrawal scale, Adaptive Skills improved for all participants, while P1 to P5 improved on the Anxiety scale. In Table 5, higher scores on each scale represent greater difficulties in social behavior. In terms of the SRS-2, Participants P2 and P4 both improved in social motivation, while Participant P6 improved in social communication. Participant P7 improved in both social awareness and social motivation while Participant P5 had improvements across all SRS-2 scales.

Table 5: SRS-2 Pre- and Post-Intervention Results for All Participants

| Participants                                | P1  |      | P2  |      | P3  |      | P4  |      | P5  |      | P6  |      | P7  |      |
|---------------------------------------------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|-----|------|
|                                             | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Total Score                                 | 83  | 84   | 65  | 67   | 68  | 68   | 69  | 78   | 91  | 78   | 57  | 62   | 69  | 74   |
| Social Awareness                            | 84  | 78   | 75  | 71   | 79  | 79   | 70  | 76   | 78  | 75   | 64  | 64   | 70  | 67   |
| Social Cognition                            | 77  | 75   | 65  | 71   | 72  | 72   | 68  | 74   | 88  | 82   | 53  | 63   | 72  | 70   |
| Social Communication                        | 80  | 89   | 64  | 70   | 69  | 69   | 71  | 86   | 87  | 78   | 61  | 60   | 60  | 72   |
| Social Motivation                           | 73  | 71   | 51  | 47   | 56  | 52   | 58  | 56   | 86  | 51   | 52  | 60   | 73  | 69   |
| Restricted Interest and Repetitive Behavior | 86  | 78   | 66  | 66   | 55  | 55   | 64  | 75   | 90  | 68   | 52  | 64   | 66  | 76   |
| Social Communication and Interaction        | 81  | 85   | 64  | 67   | 71  | 55   | 70  | 78   | 90  | 79   | 59  | 62   | 69  | 73   |

Table 6. Durbin-Conover Pairwise Comparison for Selected BASC-3 Scales (Pre- vs Post-Intervention, N = 7)

| Scale                      | Pre M (SD)    | Post M (SD)   | t      | p       | Cohen's d [95% CI]   |
|----------------------------|---------------|---------------|--------|---------|----------------------|
| Anxiety                    | 47.00 (2.52)  | 43.43 (8.52)  | 3.074  | .022*   | 0.568 [0.000, 1.664] |
| Somatization               | 53.71 (7.50)  | 49.86 (10.37) | 3.074  | .022*   | 0.426 [0.000, 1.501] |
| Internalizing Problems     | 50.14 (3.29)  | 46.14 (8.67)  | 3.074  | .022*   | 0.610 [0.000, 1.713] |
| Attention Problem          | 63.43 (7.30)  | 66.00 (8.39)  | 7.483  | < .001* | 0.327 [0.000, 1.391] |
| Withdrawal                 | 62.14 (11.10) | 57.14 (8.41)  | 6.614  | < .001* | 0.508 [0.000, 1.594] |
| Social Skills              | 30.57 (6.73)  | 34.71 (7.50)  | 15.875 | < .001* | 0.581 [0.000, 1.680] |
| Activities of Daily Living | 36.86 (10.57) | 41.71 (9.48)  | 3.074  | .022*   | 0.484 [0.000, 1.566] |
| Behavioral Symptoms Index  | 60.43 (4.96)  | 58.71 (7.11)  | 2.103  | .080    | 0.280 [0.000, 1.339] |
| Hyperactivity              | 57.86 (6.07)  | 55.14 (7.63)  | 0.935  | .386    | 0.394 [0.000, 1.465] |

Note. M = Mean; SD = Standard Deviation; t = Durbin-Conover test statistic (df = 6); p = two-tailed p-value; 95% CI = confidence interval for Cohen's d. Lower post-intervention scores indicate improvement for Hyperactivity through Behavioral Symptoms Index; higher post-intervention scores indicate improvement for Social Skills and Activities of Daily Living. Highlighted blue rows = statistically significant. \* p < .05. Full results for all 18 BASC-3 scales are available in the APPENDIX.

The Behavioral Symptoms Index (BSI) cluster includes the scales of hyperactivity, aggression, depression, attention problems, atypicality, and withdrawal which reflect overall problem behavior levels. This cluster reflects the tendency of autistic children to be easily distracted, to be overly active, to withdraw from others to avoid social contact. A lower Behavioral Symptoms Index value implies fewer related problems in this cluster. As seen in Fig. 5 the Behavioral Symptoms Index value decreased for 4 out of 7 participants after the intervention training. Participants P2 and P5 improved from the at-risk class to the average class in this cluster.

Notably, Participants P2 and P5 crossed the clinical threshold from the at-risk classification to the average range, representing clinically meaningful change beyond mere score reduction. This finding suggests the VRVM intervention was particularly effective in reducing the tendency towards social withdrawal and distractibility, behaviors that are directly relevant to school transition success. The three participants who did not show BSI improvement (P4, P6, P7) showed mixed profiles, P4's score increased, which may reflect heightened awareness of the new school environment rather than a genuine deterioration.

Table 7. Durbin-Conover Pairwise Comparison for SRS-2 Scales (Pre- vs Post-Intervention, N = 7)

| Scale                                 | Pre M (SD)    | Post M (SD)   | t     | p            | Cohen's d [95% CI]   |
|---------------------------------------|---------------|---------------|-------|--------------|----------------------|
| <b>Total Score</b>                    | 71.71 (11.47) | 73.00 (7.68)  | 5.084 | <b>.002*</b> | 0.132 [0.000, 1.182] |
| <b>Social Awareness</b>               | 74.29 (6.75)  | 72.86 (5.70)  | 3.813 | <b>.009*</b> | 0.229 [0.000, 1.284] |
| Social Cognition                      | 70.71 (10.77) | 72.43 (5.74)  | 0.000 | 1.000        | 0.199 [0.000, 1.252] |
| Social Communication                  | 70.29 (10.06) | 74.86 (10.17) | 2.103 | .080         | 0.452 [0.000, 1.530] |
| Social Motivation                     | 64.14 (13.28) | 61.14 (10.73) | 2.103 | .080         | 0.248 [0.000, 1.305] |
| Restricted Interest & RB              | 68.43 (14.47) | 68.86 (8.13)  | 1.111 | .309         | 0.037 [0.000, 1.084] |
| <b>Social Comm. &amp; Interaction</b> | 72.00 (10.42) | 71.29 (10.53) | 3.074 | <b>.022*</b> | 0.068 [0.000, 1.117] |

Note. M = Mean; SD = Standard Deviation; t = Durbin-Conover test statistic (df = 6); p = two-tailed p-value; 95% CI = confidence interval for Cohen's d. Higher SRS-2 scores indicate greater social impairment; therefore decreased post-intervention scores reflect improvement. Highlighted blue rows = statistically significant. \* p < .05. RB = Repetitive Behavior.

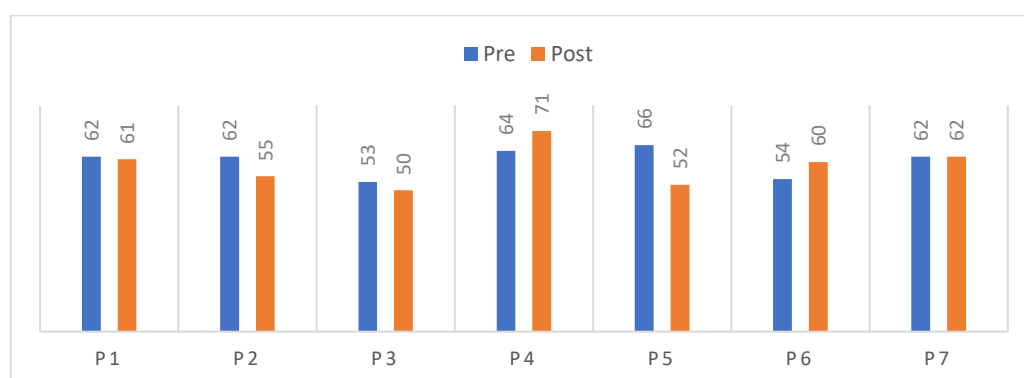


Fig. 5: Pre- and post-intervention Behavioral Symptoms Index (BSI) scores for all participants (P1–P7). Downward trends indicate improvement. Participants P2 and P5 crossed from the at-risk to the average classification band following the VRVM intervention, reflecting clinically significant improvement in composite behavioral functioning relevant to school adaptation.

The SRS-2 Social Motivation scale has shown that the VRVM intervention helped autistic children reduce symptoms related to the social motivation. Symptoms in the social motivation cluster include being overly dependent on adults, and being reluctant to join group activities, etc. As seen in Fig. 6, 6 out of 7 participants showed improvement after the intervention training with the post-intervention results being lower than the pre-intervention results. Remarkably, participant P5's score dropped from 86 to 51, which implies the participant improved from the severe range to the normal range. Participant P1 was the only participant who did not show improvement on this scale.

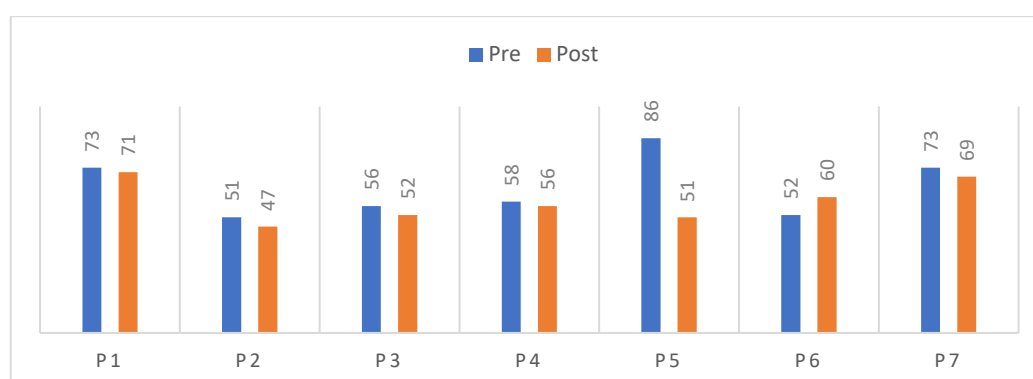


Fig. 6: Pre- and post-intervention Social Motivation scores (SRS-2) for all participants (P1–P7). Downward trends indicate improvement (reduced social motivational difficulties). Six of seven participants showed post-intervention improvement. Participant P5 shifted from the severe range (score 86) to the normal range (score 51), the most pronounced individual improvement observed in this study.

## 4.0 DISCUSSION

In this section, the data from the intervention training are benchmarked against the same scales reported in other studies of CBT, IFP, PC-CARE, BBI, ImPACT and PCIT to discuss the performance of the VRVM and its strengths and weaknesses.

The results of this pilot study provide the preliminary evidence that combining VR with POV video modelling produces meaningful behavioral improvements specifically in the context of school transition for autistic children a gap that was previously unaddressed in the literature. The medium-to-large effect sizes on hyperactivity ( $d = 1.247$ ), Behavioral Symptoms Index ( $d = 0.739$ ), and social awareness ( $d = 0.546$ ) demonstrate that VRVM is not only technically feasible but is also associated with measurable changes on standardized clinical instruments. Importantly, the improvements observed were in domains that are directly relevant to school transition: reduced hyperactivity supports the ability to remain calm in a classroom; improved social awareness and social motivation facilitate peer interactions; and reduced Behavioral Symptom Index scores suggest a broader reduction in school-transition-related behavioral difficulties. While the absence of a control group limits causal conclusions, these preliminary effect sizes are sufficient to justify a larger controlled trial to confirm the intervention's efficacy.

Table 8 presents a consolidated comparison of VRVM effect sizes against five published benchmark interventions across all relevant BASC-3 and SRS-2 scales. Visual representations of these comparisons are retained in Figs. 7–11. For Externalizing Problems, VRVM ( $d = 0.545$ ) outperformed CBT and fell below PC-CARE ( $d = 0.84$ ), the latter of which involves real-time therapist coaching a more resource-intensive modality than the self-directed VRVM approach.

Table 8: Consolidated Benchmarking Summary - Effect Sizes Across Interventions and Scales

| Scale                                 | VRVM  | CBT   | IFP   | PC-CARE | ImPACT | BBI  |
|---------------------------------------|-------|-------|-------|---------|--------|------|
| Externalizing Problems                | 0.545 | —     | —     | 0.84    | —      | —    |
| Internalizing Problems                | 0.450 | 0.271 | 0.025 | —       | —      | N/A* |
| Behavioral Symptom Index              | 0.739 | —     | 0.163 | —       | —      | —    |
| Social Motivation (SRS-2)             | 0.493 | —     | —     | —       | 0.418  | —    |
| Restricted Interests & Rep. Behaviors | 0.434 | —     | 0.791 | —       | —      | —    |

\* BBI:  $n=1$ , effect size not calculable. — = scale not reported in that study. All VRVM values: this study ( $n=7$ , pilot). Values from benchmark studies sourced from cited references [23–28].

For Internalizing Problems, VRVM ( $d = 0.450$ ) outperformed both CBT ( $d = 0.271$ ) and the Individual Fitness Program ( $d = 0.025$ ), suggesting that immersive VR-based social training may be more effective than exercise-based programmes for reducing internalizing symptoms. The Behavioral Symptom Index showed the strongest VRVM effect ( $d = 0.739$ ), approaching a large effect size and indicating broad improvement in composite behavioral functioning. For Social Motivation, VRVM ( $d = 0.493$ ) performed comparably to ImPACT ( $d = 0.418$ ), a validated parent-implemented social communication programmes. VRVM performed less strongly than IFP for Restricted Interests and Repetitive Behaviors (VRVM  $d = 0.434$  vs IFP  $d = 0.791$ ), which is expected given that the VRVM intervention was not specifically designed to target repetitive behaviors. The full scale-by-scale comparison is summarized in Table 8; Figs. 7–11 are retained as visual supplements.

To identify the depression and anxiety levels of autistic children, the results of the Internalizing Problems scale provided valuable insight. Fig. 8 shows that VRVM has a practically significant effect size of  $d = 0.450$  for Internalizing Problems, compared to CBT ( $d = 0.271$ ) and IFP ( $d = 0.025$ ). This suggests that VRVM may be more effective in reducing internalizing issues than CBT and IFP. The implementation of CBT may require further research to identify a better way to conduct the therapy without autistic individuals physically attending. The BBI study had only one participant, therefore, its effect size could not be calculated.

The Behavioral Symptoms Index, which clusters attention problems, atypicality, and withdrawal showed a practically significant effect size for VRVM of  $d = 0.739$ , indicating a nearly large effect [38] as shown in Fig. 9. Compared with IFP, VRVM is more effective in addressing related problems, with IFP showing a negligible effect size [40]. By providing personalized fitness training sessions for autistic individuals, IFP may not effectively improve Behavioral Symptoms Index components such as withdrawal which reflects the challenges autistic individuals face in social contact. In contrast, the VM in the VRVM intervention emphasizes meeting new friends and new teachers in the school setting which helps autistic children prepare themselves for social contact.

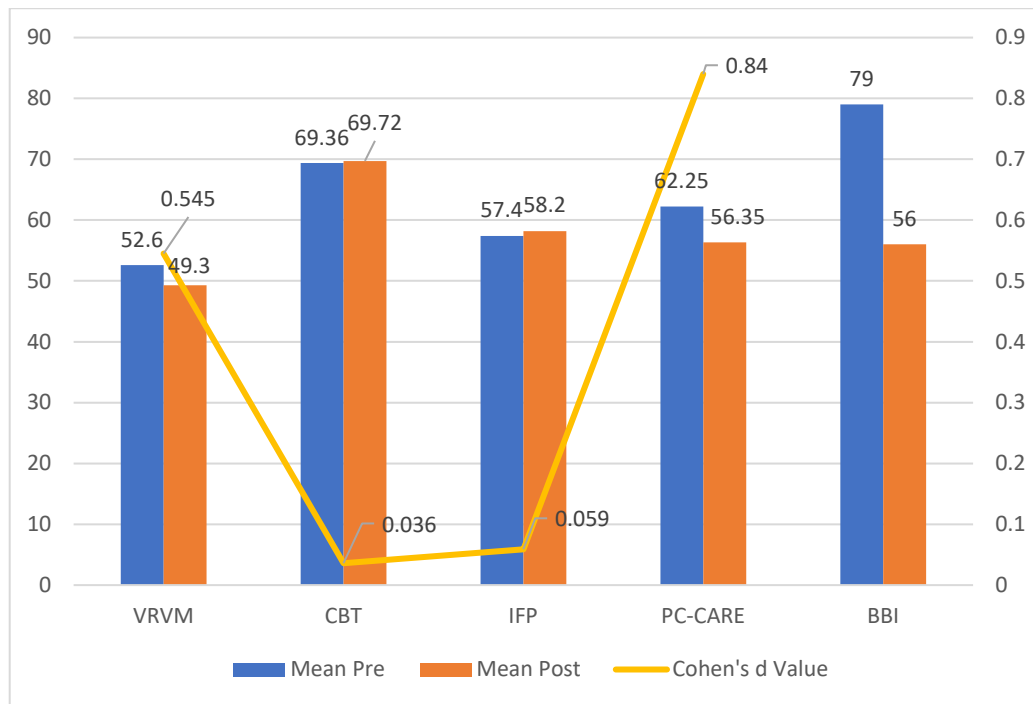


Fig. 7: Benchmarking for Externalizing Problems Cluster

The Social Motivation scale provided insight into the extend to which autistic children are motivated to engage in social-interpersonal behavior. As shown in Fig. 10, VRVM had an effect size of  $d = 0.493$  which is slightly higher than ImPACT in the Social Motivation cluster from SRS-2. The effect size comparison indicates that the symptoms in the social motivation cluster are reduced after the VRVM intervention training, such as being less fidgety when alone, and more willing to join group activities.

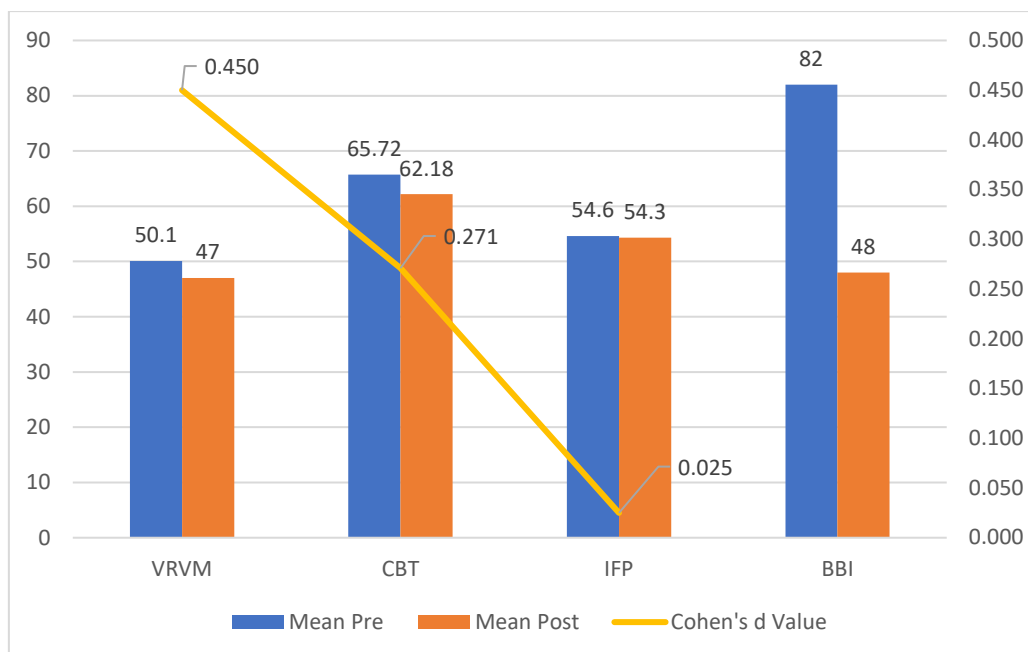


Fig. 8: Benchmarking for Internalizing Problems Cluster

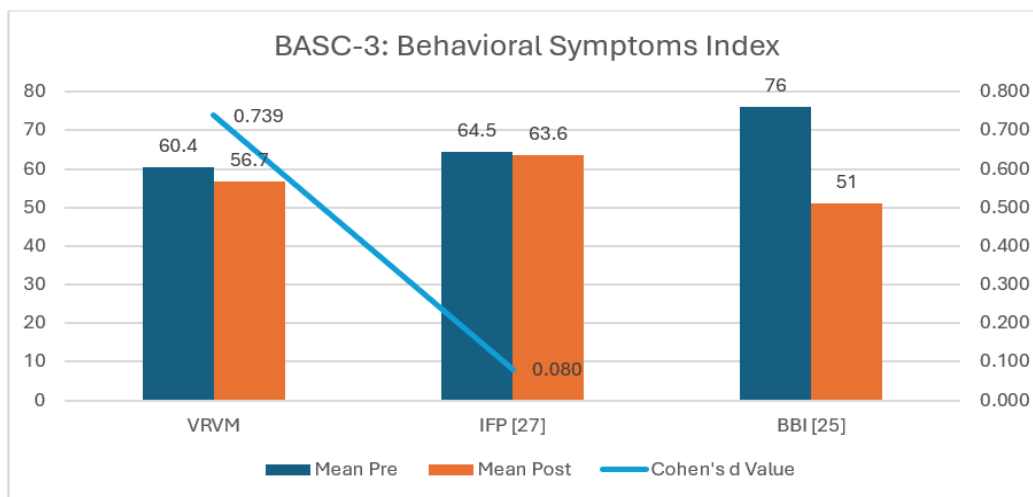


Fig. 9: Benchmarking for Behavioral Symptoms Index Cluster

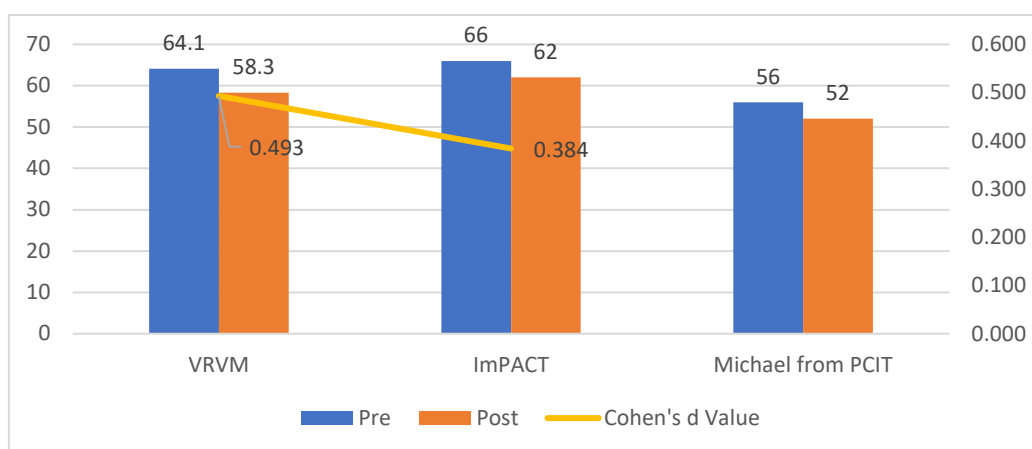


Fig. 10: Benchmarking for Social Motivation Cluster

Moreover, stereotypical behaviors were identified using the scale of Restricted Interests and Repetitive Behaviors. When VRVM's effect size for Restricted Interests and Repetitive Behaviors was compared with that of the IFP intervention, IFP showed a large effect size ( $d = 0.791$ ), as shown in Fig. 11. The VRVM intervention has a practically significant effect size of  $d = 0.434$  which suggests that the frequency with which participants behaved oddly and showed unusual sensory interests decreased.

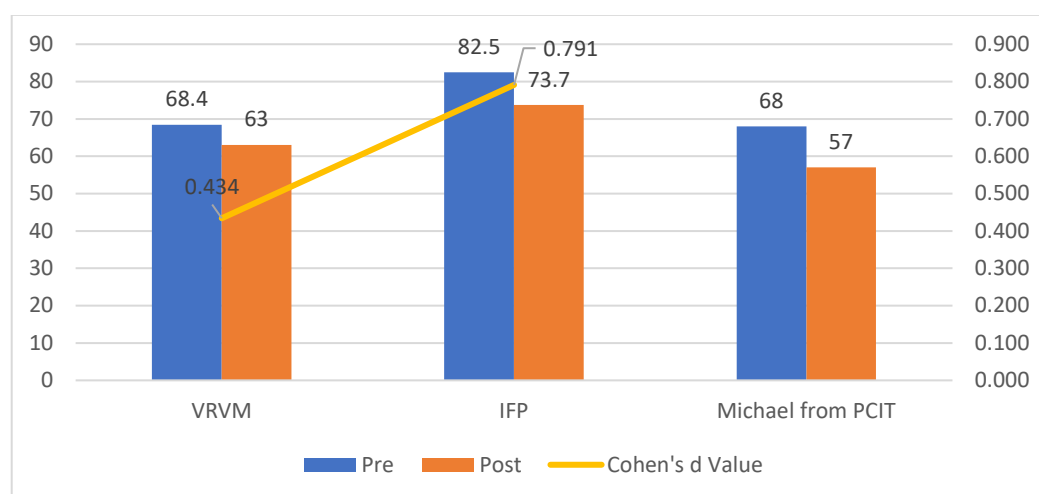


Fig. 11: Benchmarking for Restricted Interests and Repetitive Behaviors Cluster

## 5.0 CONCLUSIONS

This pilot pre-post feasibility study demonstrated that the successful development of the VRVM intervention or training autistic children to adapt to a new school. The preliminary findings suggest that the VRVM intervention improved autistic children's hyperactivity issues and Behavioral Symptoms Index scores, potentially helping them make new friends and focus during lesson. The near-large effect size for the Behavioral Symptoms Index  $d = 0.739$  suggests that the intervention helps them make social contact with friends and teachers in the new school, leading to better school adaptation. The large effect size for hyperactivity  $d = 1.247$  indicates that related issues were reduced after the intervention training. Therefore, they can suggest that the children may be better able to attend school and calm themselves during the lesson. The customization feature that allows parents to insert an image of the actual school image appear to engage the children, as most of them preferred the video featuring their school to videos without it. In this way, autistic children can use the virtually presented VM to familiarize themselves with the school they will soon attend. The VRVM intervention supports autistic children in several aspects of adapting to a new school, such as social contact with new classmates and joining group activities.

The current study was limited by a small sample size of seven participants, three of whom were girls, due to the time constraint that the training had to be completed before school term began. The small sample size reduces the generalizability of the findings. Furthermore, several threats to internal validity must be acknowledged. The absence of a control group means that improvements cannot be causally attributed to the VRVM intervention alone, as maturation, parental preparation, or general school readiness may have contributed to the observed changes. A control group was not included due to ethical constraints, as withholding a potentially beneficial pre-school intervention from eligible children was not approved by the ethics committee (SERC approval No. U/SERC/279/2023), along side the small eligible population at the partnering school and the logistical time constraints of the school calendar. Additionally, the pre-post design does not control for history effects, including other concurrent supports the children may have received during the intervention period. Finally, effect sizes from samples of  $n = 7$  are prone to upward bias and should be treated as pilot-level estimates only.

Future research should seek to replicate this study with larger samples and include a randomized control group to establish causal efficacy. Longitudinal follow-up assessments, for example at three and six months post-school entry, would help determine whether intervention gains are sustained over time. The optimal number and duration of VRVM sessions remain to be established, and future studies should systematically investigate dosage effects. Expanding the VR storylines to cover additional school scenarios, identified through consultation with parents and teachers, would broaden the intervention's scope. A co-design component involving parents and special educators is also recommended to further refine the customization features. Finally, integrating qualitative methods such as parent interviews and observational data would enrich understanding of individual children's school transition experiences beyond what standardized scales alone can capture.

Benchmarking against other studies suggests that VRVM helps autistic children with externalizing and internalizing problems with better performance than CBT and IFP. Although VRVM performed slightly less well than IFP on Restricted Interests and Repetitive Behaviors, it showed a larger, practically significant effect size on the Behavioral Symptoms Index. In addition, VRVM showed a large effect size than ImPACT for Social Motivation.

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## AUTHOR CONTRIBUTIONS

- Yi Ling Ang: methodology, validation, investigation, writing and original draft preparation.
- Sima Ahmadpour\*: formal analysis, visualization, writing, review and editing.
- Hock Guan Goh: conceptualization, formal analysis, resource preparation, supervision, writing, review and editing.
- Chen Kang Lee: methodology, supervision, writing, review and editing.
- Kai Shuen Pheh: conceptualization, validation, resource preparation, supervision, writing, reviewing and editing.

All authors have read and agreed to the published version of the manuscript.

## REFERENCES

- [1] L. Carnevali *et al.*, “Time contingency and social engagement shape interaction choices in autism and neurotypical development,” *Sci. Rep.*, vol. 15, no. 1, p. 36757, Oct. 2025, doi: 10.1038/s41598-025-20738-8.
- [2] Y. Ishizaki *et al.*, “Eye gaze differences in school scenes between preschool children and adolescents with high-functioning autism spectrum disorder and those with typical development,” *Biopsychosoc. Med.*, vol. 15, no. 1, p. 2, Dec. 2021, doi: 10.1186/s13030-020-00203-w.
- [3] B. B. Chen and G. Yakubova, “Evaluating the Effects of Video-Based Intervention to Teach Vocational Skills to Transition-Age Youth with Autism Spectrum Disorder: an Evidence-Based Systematic Review,” *Rev. J. Autism Dev. Disord.*, vol. 10, no. 1, pp. 22–37, Mar. 2023, doi: 10.1007/s40489-021-00282-7.
- [4] C. K. Syriopoulou–Delli and K. Sarri, “Video-based instruction in enhancing functional living skills of adolescents and young adults with autism spectrum disorder and their transition to independent living: a review,” *Int. J. Dev. Disabil.*, vol. 68, no. 6, pp. 788–799, Nov. 2022, doi: 10.1080/20473869.2021.1900504.
- [5] K. McConnell, C. Keenan, C. Storey, and A. Thurston, “Video-based interventions promoting social behavioural skills for autistic children and young people: An evidence and gap map,” *Campbell Systematic Reviews*, vol. 20, no. 2, Jun. 2024, doi: 10.1002/cl2.1405.
- [6] A. Granić N. Marangunić and A. Barišić, “Technology acceptance model in educational contexts: A systematic review,” *Br J Educ Technol*, 50: 2572-2593 2019, <https://doi.org/10.1111/bjet.12864>.
- [7] K. Megari, C. K. Frantzezou, Z. A. Polyzopoulou, and S. K. Tzouni, “Neurocognitive features in childhood & adulthood in autism spectrum disorder: A neurodiversity approach,” *International Journal of Developmental Neuroscience*, vol. 84, no. 6, pp. 471–499, Oct. 2024, doi: 10.1002/jdn.10356.
- [8] D. B. Drageset and K. J. Crippen, “A systematic review of the use of virtual reality in formal, informal, and non-formal learning environments for individuals with autism,” *Interactive Learning Environments*, vol. 33, no. 3, pp. 1929–1944, Mar. 2025, doi: 10.1080/10494820.2024.2405702.
- [9] M. Schmidt, C. Schmidt, N. Glaser, D. Beck, M. Lim, and H. Palmer, “Evaluation of a spherical video-based virtual reality intervention designed to teach adaptive skills for adults with autism: a preliminary report,” *Interactive Learning Environments*, vol. 29, no. 3, pp. 345–364, Apr. 2021, doi: 10.1080/10494820.2019.1579236.
- [10] P. Witoonchart and Y.-J. Huang, “Using Video Modeling in Enhance Social Skills to Children With Autism: A Literature Review,” *Ramathibodi Medical Journal*, vol. 47, no. 2, pp. 46–56, Jun. 2024, doi: 10.33165/rmj.2024.47.2.266424.
- [11] B. Selaskowski *et al.*, “Clinical adoption of virtual reality in mental health is challenged by lack of high-quality research,” *npj Mental Health Research*, vol. 3, no. 1, p. 24, May 2024, doi: 10.1038/s44184-024-00069-8.
- [12] N. Glaser, N. Newbutt, H. Palmer, and M. Schmidt, “Video-Based Virtual Reality Technology for Autistic Users: An Emerging Technology Report,” *Technology, Knowledge and Learning*, vol. 28, no. 2, pp. 925–935, Jun. 2023, doi: 10.1007/s10758-022-09594-x.
- [13] E. Fitzgerald *et al.*, “Comparing the effectiveness of virtual reality and video modelling as an intervention strategy for individuals with Autism Spectrum Disorder: Brief report,” *Dev. Neurorehabil.*, vol. 21, no. 3, pp. 197–201, Apr. 2018, doi: 10.1080/17518423.2018.1432713.
- [14] M. Moustaka, L. Kossyvakaki, and E. Terlektsi, “Using point-of-view video modelling with young autistic students: a systematic literature review,” *Int. J. Dev. Disabil.*, pp. 1–14, Jul. 2025, doi: 10.1080/20473869.2025.2533936.

- [15] J. Chen *et al.*, “Virtual reality enhances the social skills of children with autism spectrum disorder: a review,” *Interactive Learning Environments*, 32(5), pp. 2321–2342, doi: 10.1080/10494820.2022.2146139.
- [16] L. Li *et al.*, “Research on the improvement of daily living skills of children with autism in virtual campus environments,” *Sci. Rep.*, vol. 15, no. 1, p. 30102, Aug. 2025, doi: 10.1038/s41598-025-08224-7.
- [17] A. Wiebe *et al.*, “Virtual reality-assisted prediction of adult ADHD based on eye tracking, EEG, actigraphy and behavioral indices: a machine learning analysis of independent training and test samples,” *Transl. Psychiatry*, vol. 14, no. 1, p. 508, Dec. 2024, doi: 10.1038/s41398-024-03217-y.
- [18] K. I. Kotsopoulos, M. G. Katsounas, A. Sofios, C. Skaloumbakas, A. Papadopoulos, and A. Kanelopoulos, “VRESS: Designing a platform for the development of personalized Virtual Reality scenarios to support individuals with Autism,” in *2021 12th International Conference on Information, Intelligence, Systems & Applications (IISA)*, IEEE, Jul. 2021, pp. 1–4. doi: 10.1109/IISA52424.2021.9555542.
- [19] M. Bellani, L. Fornasari, L. Chittaro, and P. Brambilla, “Virtual reality in autism: state of the art,” *Epidemiol. Psychiatr. Sci.*, vol. 20, no. 3, pp. 235–238, Sep. 2011, doi: 10.1017/S2045796011000448.
- [20] M. Sait, A. Alattas, A. Omar, S. Almalki, S. Sharf, and E. Alsaggaf, “Employing Virtual Reality Techniques in environment adaptation for autistic children,” *Procedia Comput. Sci.*, vol. 163, pp. 338–344, 2019, doi: 10.1016/j.procs.2019.12.116.
- [21] S. C. Polychronis, A. Johnson, R. J. Thelin, D. L. Eggett, and J. Christensen, “Use of an App With Embedded Video Modeling to Increase Eye Contact,” *Focus Autism Other Dev. Disabl.*, vol. 38, no. 3, pp. 199–208, Sep. 2023, doi: 10.1177/10883576221124805.
- [22] T. Cardon, N. Wangsgard, and N. Dobson, “Video Modeling Using Classroom Peers as Models to Increase Social Communication Skills in Children with ASD in an Integrated Preschool,” *Educ. Treat. Children*, vol. 42, no. 4, pp. 515–536, 2019, doi: 10.1353/etc.2019.0024.
- [23] V. A. Green *et al.*, “Use of Video Modeling to Increase Positive Peer Interactions of Four Preschool Children with Social Skills Difficulties,” *Educ. Treat. Children*, vol. 36, no. 2, pp. 59–85, 2013, doi: 10.1353/etc.2013.0016.
- [24] J. L. Kouo, “The Effectiveness of a Packaged Intervention Including Point-of-View Video Modeling in Teaching Social Initiation Skills to Children With Autism Spectrum Disorders,” *Focus Autism Other Dev. Disabl.*, vol. 34, no. 3, pp. 141–152, Sep. 2019, doi: 10.1177/1088357618815887.
- [25] C. Rastelli, A. Greco, Y. N. Kenett, C. Finocchiaro, and N. De Pisapia, “Simulated visual hallucinations in virtual reality enhance cognitive flexibility,” *Sci. Rep.*, vol. 12, no. 1, p. 4027, Mar. 2022, doi: 10.1038/s41598-022-08047-w.
- [26] H. Chen, X. Zhang, Z. Chen, Y. Ren, and R. Liu, “Auxiliary diagnostic method for children with autism spectrum disorder based on virtual reality and eye-tracking technology,” *Sci. Rep.*, vol. 15, no. 1, p. 40552, Nov. 2025, doi: 10.1038/s41598-025-24243-w.
- [27] D. Parsons, N. J. Wilson, S. Vaz, H. Lee, and R. Cordier, “Appropriateness of the TOBY Application, an iPad Intervention for Children with Autism Spectrum Disorder: A Thematic Approach,” *J. Autism Dev. Disord.*, vol. 49, no. 10, pp. 4053–4066, Oct. 2019, doi: 10.1007/s10803-019-04115-9.
- [28] L. Carnevali *et al.*, “Time contingency and social engagement shape interaction choices in autism and neurotypical development,” *Sci. Rep.*, vol. 15, no. 1, p. 36757, Oct. 2025, doi: 10.1038/s41598-025-20738-8.
- [29] P. Pérez-Fuster *et al.*, “Pictogram room augmented reality technology games improve body knowledge, imitation, and joint attention skills in autistic children with intellectual disability,” *Sci. Rep.*, vol. 15, no. 1, p. 34966, Oct. 2025, doi: 10.1038/s41598-025-19085-5.

- [30] M. L. da Silva, D. Gonçalves, and H. Silva, "User-tuned Content Customization for Children with Autism Spectrum Disorders," *Procedia Comput. Sci.*, vol. 27, pp. 441–448, 2014, doi: 10.1016/j.procs.2014.02.048.
- [31] T. P. Bruni, "Test Review: Social Responsiveness Scale–Second Edition (SRS-2)," *J. Psychoeduc. Assess.*, vol. 32, no. 4, pp. 365–369, Jul. 2014, doi: 10.1177/0734282913517525.
- [32] K. Gergoudis *et al.*, "Psychometric Study of the Social Responsiveness Scale in Phelan–McDermid Syndrome," *Autism Research*, vol. 13, no. 8, pp. 1383–1396, Aug. 2020, doi: 10.1002/aur.2299.
- [33] Cecil R. Reynolds and Randy W. Kamphaus, "Behavior Assessment System for Children, Third Edition (BASC–3)," *Pearson Education, Inc*, 2019.
- [34] S.-I. Ji, H. Park, S. A. Yoon, and S.-B. Hong, "A Validation Study of the CARS-2 Compared With the ADOS-2 in the Diagnosis of Autism Spectrum Disorder: A Suggestion for Cutoff Scores," *Journal of the Korean Academy of Child and Adolescent Psychiatry*, vol. 34, no. 1, pp. 45–50, Jan. 2023, doi: 10.5765/jkacap.220027.
- [35] M. Schmidt, N. Glaser, H. Palmer, C. Schmidt, and W. Xing, "Through the lens of artificial intelligence: A novel study of spherical video-based virtual reality usage in autism and neurotypical participants," *Computers & Education: X Reality*, vol. 3, p. 100041, Dec. 2023, doi: 10.1016/j.cexr.2023.100041.
- [36] W. J. Conover, *Practical nonparametric statistics*. John Wiley & sons, 1999.
- [37] L. V Hedges and I. Olkin, *Statistical methods for meta-analysis*. Academic press, 2014.
- [38] S. Pogrow, "How Effect Size (Practical Significance) Misleads Clinical Practice: The Case for Switching to Practical Benefit to Assess Applied Research Findings," *Am. Stat.*, vol. 73, no. sup1, pp. 223–234, Mar. 2019, doi: 10.1080/00031305.2018.1549101.
- [39] C. C. Serdar, M. Cihan, D. Yücel, and M. A. Serdar, "Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies," *Biochem. Med. (Zagreb)*, vol. 31, no. 1, pp. 27–53, Feb. 2021, doi: 10.11613/BM.2021.010502.
- [40] L. V. Hedges, "Distribution Theory for Glass's Estimator of Effect size and Related Estimators," *Journal of Educational Statistics*, vol. 6, no. 2, pp. 107–128, Jun. 1981, doi: 10.3102/10769986006002107.