# Gaining presence for neurodiverse students in hybrid classes using WebMoti: A case study

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**Abstract.** Neurodiverse (ND) students frequently encounter barriers to participation in hybrid higher education due to limited accommodations and inaccessible technologies. Addressing this challenge, we evaluated WebMoti, a telepresence system designed with inclusive principles to enhance classroom engagement for remote ND students. WebMoti integrates video conferencing, customizable sensory controls, multiple cameras, and a robotic "hand" to create a physical presence and support autonomy. Through a three-week longitudinal case study with three ND students and their instructors, we examined engagement, presence, and usability. Findings indicate that WebMoti improved perceived presence and enabled active participation, with customizable features and physical classroom representation central to user satisfaction. Instructors valued the system for facilitating interaction, though audio management challenges were noted. This research advances the inclusive design of information systems by demonstrating how embodied telepresence and user-driven customization can foster digital inclusion for marginalized learners in hybrid learning environments.

**Keywords:** Neurodiversity, Digital inclusion, Telepresence

## 1 Introduction and Background

Neurodiversity refers to the variations in neurological development and functioning that influence cognition, behaviour, and learning processes [1]. This concept includes a range of neurodevelopmental conditions such as Attention Deficit Hyperactivity Disorder (ADHD) along with other related conditions like generalized anxiety and Social Anxiety, each presenting unique characteristics and specific needs. In the education sector, while there can be substantial support for ND students in elementary, middle, and high school, these resources and accommodations often diminish at the post-secondary level, leaving many students without the necessary support to thrive in higher education. As more ND individuals are pursuing higher education, the demand for more inclusive academic environments has increased [2].

Despite increasing post-secondary enrolment among neurodiverse (ND) students, significant barriers to academic success persist. One of the common accommodations for neurodiverse students is hybrid learning where the ND student attends class virtually while others attend in-person. While virtual attendance can help ND students manage sensory overload, it also introduces barriers such as loss of physical presence, social interaction, presence, and collaboration [3].

While the knowledge and acceptance of the technology for virtual classes have improved, the ability to manage a hybrid environment where there is a combination of in-person and virtual attendance remains limited, particularly for ND students. One issue is that students who attend virtually are often overlooked or forgotten by the instructor as they do not have sufficient presence in the classroom [4]. When a student lacks presence, it can lead to feelings of isolation and disconnectedness [5]. These social disadvantages could then have a negative impact on students' engagement, motivation, and sense of belonging, which may, in turn further affect their academic performance [6].

Research has been conducted using humanoid-like robots in classrooms in attempts to affect improved access for students with disabilities needing to attend virtually (e.g., [7, 8] Much of this has focused on elementary or secondary students attending virtually and being represented by a physical presence with many features such as facial expressions. Findings from this research indicate that virtual students experience increased sense of social presence, engagement across cognitive, behavioural and emotional factors, and improved interactions with instructors and classmates. However, most of these robots are costly and require technical support. WebMoti is designed as a simple addition to existing and typical conferencing technologies that do not require extensive setup or configuration by instructors. Rather, it is intended to reduce the technical workload on instructors while attempting to increase opportunities for participation of university level students.

To advance inclusive hybrid learning, this paper presents a novel technology, called WebMoti, which is a hardware and software system designed to enhance the presence and participation of remote neurodiverse students. WebMoti offers customizable camera and audio controls and a physical “raise hand” function, a robotic hand placed in the classroom, enabling virtual students to visibly signal participation and address the risk of being overlooked.

While previous research has explored the general benefits of telepresence technologies [9], little is known about how such systems affect ND students’ ability to participate meaningfully in academic discourse, regulate sensory input, and experience a sense of classroom presence. To address this gap, we conducted a longitudinal, mixed-methods case study involving three ND students. The research questions for this research are: 1) What is the impact of WebMoti on students' ability to ask/answer questions, participate in class discussions, have presence, and balance sensory needs?; and 2) How usable and useful is WebMoti for attending and participating in a class for neurodiverse students?

## 2 WebMoti system design

WebMoti was co-developed with ND students and researchers with lived experience using an iterative design methodology of development and testing over a one-year period, reflecting inclusive design principles of participatory development, user autonomy, and flexibility [4]. The core purpose of WebMoti was to improve presence of virtual ND students in hybrid classes, including participation, through a physical

classroom representation, access to classroom audio and visuals (e.g., the board), and a customizable video conferencing interface.

WebMoti features a robotic hand controlled by remote students to raise and wave, allowing them to request the instructor's attention and physically occupy classroom space. There is also a microphone controlled by the instructor through a tablet, which provides access to the classroom audio such as when an in-class student wants to ask a question. The WebMoti application was hosted as a web-based application so participants could access it from home. The application allowed them to transmit commands to the Raspberry Pis and attend the class using Twilio's video conferencing service.

The classroom's Rode NTG2 shotgun microphone can be repositioned by the instructor using a tablet interface that displays a grid of seating locations. The robotic hand is controlled by a 5V stepper motor connected to a Raspberry Pi 4. When a remote student selects the "Raise hand", the stepper motor activates and moves the hand in a 180º arc. A 4K Logitech Brio camera with a 3x zoom control captures the whiteboard and allows the remote student to zoom in on the board. A second camera, a Logitech C930e 1080p camera, captures a 120° view of in-person students. Figure 1 shows the location and physical layout of the WebMoti hardware. The robotic hand was placed at the front of the classroom, close to the instructor's podium and within the instructor's direct line of sight. While the system is designed to be used by multiple users simultaneously, it was initially evaluated with only one user per class.

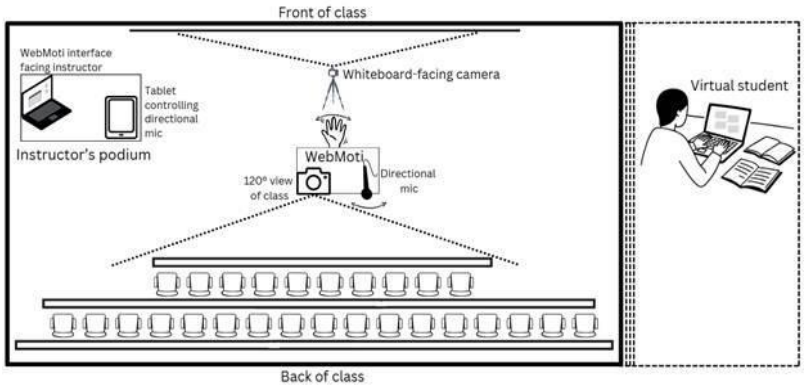


**Figure 1**: Birdseye image of WebMoti set up in the classroom.

The virtual student interface allows users to toggle between cameras, adjust audio settings, and use standard video conferencing options. The virtual students are also able to customize how they view the interface by changing the screens from gallery view to speaker view, which enables the whiteboard close-up. In the classroom, an orange-coloured mechanical hand is activated when the student uses the 'raise hand' feature. If the hand is insufficient to gain the professor's attention, virtual students can notify the professor by activating a bell sound that plays through the speakers. The hand provided a physical representation of the virtual student in the classroom [7].

# Methodology

## 2.1 Participants

Three ND full-time students, who were not the co-developers, from the same academic institution (with self-identified diagnoses of autism, ADHD, or social anxiety; severity undisclosed) from different academic programs participated in the study. There were one male and two female participants. All participants had prior experience with video conferencing platforms:

1. Participant 1: Full-time graduate student in the Faculty of Arts in their 30s with Autism Spectrum Disorder (ASD).
2. Participant 2: Full-time undergraduate student in the Faculty of Business between the ages of 18-29 with ADHD.
3. Participant 3: Full-time undergraduate student in the Faculty of Science between the ages of 18-29 with Social Anxiety.

Instructors, all male, from three different disciplines also participated in the study. Two instructors had more than 15-years teaching experience and the other had less than 2-years at the university level.

## *2.2 Study design*

A longitudinal, mixed-method case study design was selected to capture the complex, situated experiences of ND students interacting with the WebMoti system in authentic classroom settings. Following institutional research ethics approval, each student used WebMoti in three separate class sessions over a three-week period. Quantitative data (e.g., hedonia/eudaimonia scores- HEMA scale [10], telepresence ratings [11], and usability scores [12] were collected via pre-study and between-class surveys, while qualitative data from post-study interviews captured participants' nuanced perspectives and experiences. Instructors were asked to complete a pre-study questionnaire and were invited to participate in a short semi-structured interview about their experience having WebMoti in class and how it was managed while teaching.

The questionnaire data were analyzed using descriptive statistics and interview data were analyzed using a reflexive thematic analysis [13]. Two independent raters evaluated 20% of the data for reliability analysis using Interclass correlation (ICC). ICC results were >0.6 for all themes indicating strong agreement between the two raters. A single rater then coded the remaining data. The themes that evolved from the student interview data were: 1) Feeling present in class (with positive and negative modifiers); 2) Usability factors of customizability, ease of use and satisfaction; 3) Future recommendations; and 4) Technical issues. For the instructors, they were: 1) Usability including satisfaction; 2) Class management; 3) Empathy; 4) Future recommendations; and 5) Technical Issues.

## 3 Results and discussion

Figures 2 and 3 provide the distribution of the comments for the student and instructor themes.

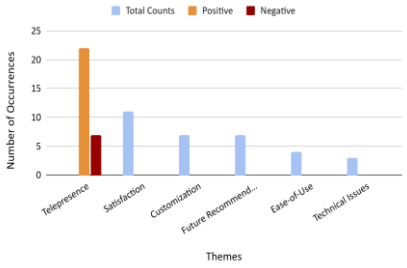


**Figure 2**: Theme counts for students

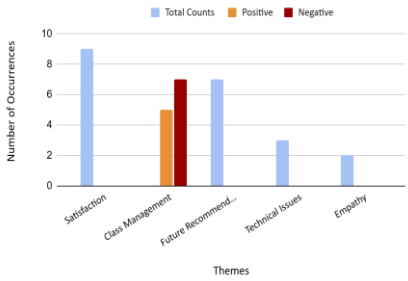


**Figure 3:** Theme counts for instructors

### 3.1 Students

Hedonia (pleasure) was represented by participant ratings from the odd-numbered questions (5 of 9) of the HEMA scale. Eudaimonia (personal growth) was measured from even-numbered question ratings (4 of 9). All participants consistently scored a 6 out of 7 on each of the five hedonic questions across each of their between-class questionnaires, M=6, IQR = 0. The themes of Satisfaction and Customization seemed to align with the high level of hedonia from the HEMA scores Specifically, Satisfaction had 11 of 61 comments, the second highest number of comments. Customization had 7 of 61 counts, the third-highest number of comments. It would seem that individuals derived pleasure, in part, from a sense of satisfaction and customizing their environment.

For eudaimonic scores the median was 6 (IQR=3) for the first class, 6 (IQR=4) for the second class, and 6 (IQR=0) for the third. P1 found WebMoti satisfying to use during their class and stated, “It definitely made me feel more like [I was] invited to participate … I'm still an active participant in the class. Participant 2 (P2) had a eudaimonia score of 6 for their first and second class and could not attend the third class. They described their experience of using WebMoti for classes as “surprising, how easier it was and how much more I participated in class compared to in-person students” and how they did not “feel as intimated to raise my hand and ask a question when I don't understand it verses [being] in class … I felt like I wasn't alone.” This sense of control gave P2 autonomy over how they wanted to be perceived when they wanted to participate in class, which could contribute to their growth as a student and sense of fulfilment. Participant 3 (P3) showed increasing feelings of eudaimonia by the third class, scoring 3 out of 7 in the first and second class and a 6 in the third. This could be due to becoming comfortable with using the system after the first two classes and seeing how it applied to their situation increasing their level of eudaimonia stating “I was able to have my space while being in direct contact with the professor.”

Telepresence was calculated by summing all ratings from the telepresence questions. A higher overall telepresence score (TS) reflected a strong sense of telepresence; the highest score being 3. Participant 1 had a TS of 3 for the first class and did not rate the second or third classes. Participant 2 had a high TS for Class 1 and 2 and did not attend the third class. Participant 3 had a TS of 0 for all three classes.

The theme of Telepresence from the interview data provides further insight into the telepresence experienced by participants. The theme Telepresence (Positive) contained the highest number of comments (22 of 61) from participants while Telepresence (Negative) had a low number of comments. P2 reported having felt a strong level of presence in the classroom in all of the classes in which they participated and stated "I felt like we were actually having a conversation … even when I didn't have my camera on it felt like I was there" and when "the hand goes up I feel like I'm actually there and the professor sees me as an actual student present in class in front of them." P1 reported feeling a strong sense of presence in the second class but not in the others. They stated how WebMoti made them feel "it was cool to be able to really feel like I was a part of the class," while using WebMoti. P1 also suggested, "I wish I could have also moved my camera [left and right] so I could be even more connected." Although P3 had a low TS their comments indicated otherwise, they stated "when I was asking questions it actually felt like I was in the class so I did not expect that."

For P1 the SUS for the first class was higher (SUS = 75) than the next two (SUS = 68 for the second and third classes). P2 had a high SUS score (SUS = 95) for the first and second classes and did not participate in the final class. P3 had a SUS of 60 in the first class, 55 in the second and 50 in the final class. The themes of Satisfaction (11 of 61) and Ease-of-Use (4 of 61) related to SUS questions about satisfaction and usability. The higher scores from the first class provided by P1 and P3 could be related to a novelty effect as their scores were reduced for the next two classes. However, P1's score remained at or above 68, which was considered good usability [12]. P1 said, "it was just in general really easy, all I had to do really is click the hand button." P2 stated "The first time I used WebMoti, I found it surprising that the teacher could hear me. Like because compared to Zoom and other hybrid options I felt like… I was in a real conversation," and "really like the hand going up and how I can navigate through each of the features. I just feel more in control."

### 3.2 Instructors

Instructors most frequently commented on Satisfaction (9 of 33), with one noting, "I really like that because when students are located remotely, I find it a bit difficult to notice when they have a question," highlighting the benefit of the raise hand feature. Empathy accounted for 2 of 33 comments, with an instructor supporting classroom accessibility for students unable to attend in person. Class Management comments were more often negative (7 of 33) than positive (5 of 33), often related to challenges remembering to control the microphone or its speed: "Often the student can't even get it. I wouldn't be able to switch the mic as quickly." By the third session, most instructors felt more comfortable managing the system.

### 3.3 Summary discussion

Our findings demonstrate that WebMoti's physical signaling and customizable interface addressed several key barriers to engagement for neurodivergent students in hybrid classrooms. Mainstream video platforms often make it difficult for ND students to gain the instructor's attention [14]. Instructors also found this capability useful as it promoted attending and not forgetting s, indicating increased comfort and agency.

The robotic hand, dual cameras, and directional microphone supported a strong sense of presence and visibility. This finding highlights the value of tangible signaling for equitable turn-taking [15]. Longer-term studies are needed to assess how sustained use of embodied telepresence tools influences classroom integration, as well as the long-term impact on ND students' sense of belonging.

WebMoti's high degree of sensory customization was a distinguishing feature, enabling participants to adjust audio and visual inputs and manage sensory overload. This control over the sensory environment contributed to comfort and focus [4]. Future work should examine the benefits of additional customization options, such as user-configurable interfaces or automated adjustments, to accommodate a broader range of sensory and executive functioning needs.

Customizable features such as dual cameras and audio controls also contributed to usability, though participants and instructors reported some challenges, particularly around camera angles and audio. An instructor commented, "Often the student will speak before I can even get [the mic] … I wouldn't be able to switch the mic as quickly." These findings align with prior studies that highlight the importance of flexibility and environmental control for user focus and engagement [16], while also noting the impact of design mismatches and novelty effects. Further development should focus on improving instructor workflows, automating routine functions, and streamlining onboarding processes for both students and educators.

This study has several limitations including its small sample size, short duration, and the challenges of recruiting ND students and instructors, which may affect transferability to other hybrid situations with ND students. As a result, the findings should be interpreted as exploratory and foundational, with future research requiring broader recruitment, and extended study periods.

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