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Teacher-Assessed Mi-Robot Training Improves Linguistic and Kinesthetic Stimulation for Children with Special Needs

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ABSTRACT

The increasing need for effective learning support for children with special needs highlights the urgency of integrating assistive technologies that enhance linguistic and kinesthetic stimulation and support teachers in instructional delivery. Conventional methods often struggle to provide consistent and engaging stimulation, particularly in digital or distance learning contexts. The objective of this study was to evaluate teachers' acceptance and perceived usefulness of the Mi-Robot for linguistic and kinesthetic stimulation. This research method is a descriptive mixed-methods study involving 20 special education teachers from 5 elementary schools in Bandung, Indonesia. Teachers received structured training in the use of Mi-Robot. Data were collected using the Mi-Robot Acceptance Scale based on the Technology Acceptance Model and an open-ended usability evaluation form. The results indicate that Mi-Robot aligns with the school curriculum and demonstrates high perceived usefulness, ease of use, positive attitudes, and strong behavioral intentions among teachers. Qualitative findings indicate that Mi-Robot effectively supports linguistic and kinesthetic stimulation through its content, functionality, and cost-effectiveness. In conclusion, Mi-Robot demonstrates strong potential as an assistive educational technology for special education in both classroom and distance-learning settings.

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1. INTRODUCTION

Individuals with special needs exhibit shared physical attributes and cognitive impairments that impact their educational development and social interactions [1]. Considering the requirements of the growing population in question, as well as those of individuals who are typically developing, is vital. Numerous studies have demonstrated the favorable outcomes associated with the utilization of technology in enhancing functional movement skills and cognitive abilities among individuals with cognitive disorders, including those diagnosed with autism. Furthermore, several previous research studies conducted on typically-developing foreign language learners have consistently reported encouraging results for Robot-Assisted Language Learning (RALL) [2–5]. Nevertheless, a notable deficiency is evident in the existing body of scholarly work on the use of robots to facilitate linguistic and kinesthetic development in individuals with exceptional needs. Enhancing linguistic and kinesthetic intelligence may improve cognitive abilities, facilitate accelerated, efficient learning, and foster stronger communication skills and self-assurance in this group. The integration of technology into educational settings has the potential to support teachers in enhancing the productivity and ease of learning for students with special needs.

According to [6], it is crucial to assess individuals' perceptions of usefulness and simplicity of use when evaluating the usability of technology. [6] established the Technology Acceptability Model (TAM) with the aim of assessing the level of acceptability exhibited by users towards information technology. The Technology Acceptance Model (TAM) examines individuals' acceptance of a given technology by considering their perceptions of its ease of use and usefulness. The two determinants in the Technology Acceptance Model (TAM) are perceived usefulness, as delineated by [6], refers to the extent to which an individual has the belief that the use of a particular technology would augment their job performance. On the other hand, perceived ease of use refers to the extent to which an individual believes that using a specific technology will require minimal effort. Attitude refers to an individual's cognitive and affective orientation toward the use of technology, specifically in terms of acceptance or rejection. This response can have significant implications for the influence of an individual's use of information technology in their professional endeavors. The outcome of acceptance or rejection then influences the individual's subsequent decision-making. The attitudes of individuals are directly influenced by their impression of usefulness and simplicity of use [7]. Additionally, changes in attitude have a crucial role in determining individuals' behavioral intention to use technology [8].

To effectively engage with teaching robots, a positive user experience (UX) is crucial, as it can profoundly influence human behavior. Hence, in order to achieve this objective, it is imperative to execute the design and evaluation of this process with precision [9]. According to Hartson et al (2018), the concept of user experience encompasses the overall impact experienced by a user when interacting with a system, device, or product, taking into account factors such as usability, usefulness, emotional impact during interaction, and the lasting memory of the experience. According to the international standard on ergonomics of human-system interaction, user experience (UX) is defined as the perceptions and responses that arise from the use or anticipated use of a particular system, product, or service (ISO, 2021). This study centers on the examination of UX evaluation, encompassing a collection of approaches and techniques employed to investigate users' perceptions of interactive services, systems, or products [10]. It is important to emphasize that the primary focus is on assessing users' experiences when engaging with social robots, rather than on analyzing users themselves.

The significance of user experience in determining the success of educational technology cannot be overstated; however, eliciting comprehensive user experience data remains a complex and multifaceted process. Previous studies have indicated that certain dimensions of user experience, such as psychophysiological responses and real-time behavioral interactions, play a crucial role in understanding how users engage with interactive systems [11]. Nevertheless, these dimensions are often insufficiently addressed, as most user experience evaluations rely predominantly on retrospective methods, including questionnaires and interviews, rather than continuous or in-situ assessments during actual product use [11]. A systematic literature review conducted by Maia and Furtado [11] revealed that 84% of user experience studies employed questionnaires, while only 16% utilized interviews, indicating a strong reliance on self-reported data. There are gaps not addressed by prior research, namely, the limited investigation of user experience in the context of social robots designed for special education, particularly from the perspective of teachers as primary users and facilitators of learning. Existing studies have largely focused on general usability or student outcomes, with insufficient attention to educators' acceptance, perceived usefulness, and practical classroom integration of robots that provide combined linguistic and kinesthetic stimulation for children with special needs.

The difference between this research and the previous one is that this study specifically examines teacher-assessed user experience and technology acceptance of Mi-Robot as a social robot designed to deliver both linguistic and kinesthetic stimulation in special education settings. Unlike prior research that emphasizes student performance or generic robotic applications, this study positions teachers' perceptions as the central evaluative framework and applies the Technology Acceptance Model (TAM) to assess perceived usefulness, perceived ease of use, attitude, and behavioral intention toward Mi-Robot.

The objectives of this study are twofold: (1) to examine the extent to which teachers accept the use of Mi-Robot for linguistic and kinesthetic stimulation for children with special needs, and (2) to evaluate teachers' perceptions of the usefulness and usability of Mi-Robot in supporting instructional activities. The contribution of this research lies in providing empirical evidence on the acceptance and usability of social robots in special education, offering practical insights for the design and implementation of teacher-centered robotic learning tools, and advancing human–robot interaction research within inclusive and special education contexts.

2. RESEARCH METHOD

2.1. Participants

The study comprises a sample of 20 elementary special education instructors from 5 schools in Bandung, West Java, Indonesia. The individuals in question were chosen from a pool of pupils who willingly submitted applications to participate in a programme involving a Mi-Robot designed to provide linguistic and kinesthetic stimulation. During their academic pursuits, educators acquire knowledge in diverse linguistic and kinesthetic stimulation. Educators instruct individuals on the broader application of social robots in family contexts.

Table 1 presents the demographic data for the participants. The average age of the participants was 36.21 years (SD = 2.53). The majority of participants had more than 11 years of work experience, and 60% were female. Additionally, 75% of participants held a bachelor's degree or higher, while 60% had not previously interacted with a social robot.

Table 1. Demographics of the Participants (n=20)

Characteristics	n (%)
Age in years, Mean ± SD	36.21 ± 2.53
Sex	
Male	8 (40)
Female	12 (60)
Education level	
Diploma	5 (25)
Bachelor or above	15(75)
Working experience in years, Mean ± SD	11.31 ± 4.22
Previous experience interacting with robot	
Yes	8 (40)
No	12 (60)

2.2. Mi-Robot development

The Mi-Robot, developed by Universitas Negeri Jakarta, supports the use of multiple linguistic and kinesthetic stimulation approaches and structures, as well as robotics components, including mechanical parts, motors, and sensors. This intellectually stimulating device encompasses verbal and kinesthetic intelligence, offering a range of difficulties. The Mi-Robot is equipped with a range of sensors, including ultrasonic and infrared cameras, that enable it to detect obstacles and navigate its path effectively. Furthermore, the device is equipped with a monitor that can engage in interactive communication with children with special needs. The controller will issue commands to the motor driver, which serves as the robot's driver, in response to sensor feedback. The sensor assembly comprises an infrared camera sensor utilized for path navigation and an ultrasonic sensor employed for collision prevention. The sensor collects the required data on operational conditions, positions, and postures. To achieve tracking objectives, the robot uses infrared sensors mounted beneath it to detect and follow dark and light-colored lines. To prevent collisions with obstacles, ultrasonic sensors are strategically positioned at the front of the car. The motor driver operates the motor in response to the input it receives. The device is equipped with two distinct operational modes: manual and automatic, as depicted in Figure 1.

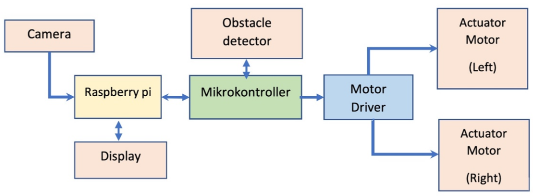

Figure 1. Diagram block of Mi-Robot

The electronics component of the robot employs the ATmega2560 microcontroller as its central control unit, while the robot motor drives are driven by four IBT_2 motor drivers. The Bluetooth module is used to communicate between the robot and the smartphone's remote control, implemented as an Android application Figure 2. Subsequently, a Printed Circuit Board (PCB) was fabricated to streamline interconnections among various subsystems. The planned printed circuit board (PCB) is depicted in Figure 3, while its hardware arrangement is illustrated in Figure 4. The Mechanical portion of the learning robot encompasses the design of a locomotion system that enables omnidirectional movement. This is achieved through the implementation of a four-wheel-drive (4WD) system, which uses four 12-V DC motors as the driving wheels. The visual representation in Figure 5 depicts the robot's original design in its entirety.

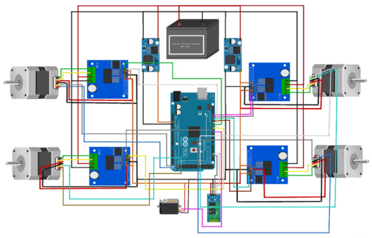

Figure 2. Schematic diagram of the electronic control system

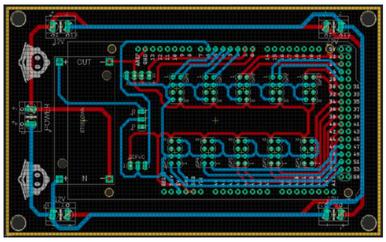

Figure 3. Design of a robot system PCB

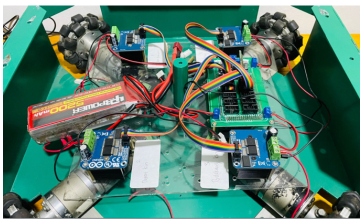

Figure 4. Electronic systems of robot

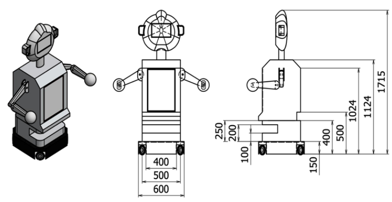

Figure 5. Mechanical design of robot

The content for linguistic and kinesthetic stimulation was developed by experts in special education and informed by a comprehensive literature review Figure 6. This development process ensured that the material was appropriate for the target users and aligned with established theoretical frameworks. The content focuses on providing structured exercises and movement activities delivered through games, music, and animated videos to enhance engagement and support learning outcomes.

Figure 6. Example of video animation for linguistic and kinesthetics stimulation

2.3. Robotics Programming Training

A total of five faculty members from the Automation Engineering Technology Department provided a total of thirty-two hours of Mi-Robot use to a group of twenty teachers, with the aim of enhancing linguistic and kinesthetic intelligence. The combination of Mi-Robot and an animated movie was utilized in the training session. Consequently, the participants were introduced to Mi-Robot and gained insights into the shared characteristics and distinctions between the two devices. At the outset of the training session, participants designed Mi-Robot, guided by a comprehensive manual meticulously produced by the researchers. Subsequently, a comparative analysis of the components of the Mi-Robot, including the engine, mechanical elements, and sensors, was conducted on both the actual and virtual manifestations of the Mi-Robot. The educators provided the participants with information regarding each component and conducted multiple sample applications in their presence. Following the preliminary training, participants were assigned complex programming problems in Mi-Robot to be independently completed. After the training programme, participants were expected to complete the Search and Rescue task, the last challenge that requires all Mi-Robot module expertise. Participants applied their knowledge of solo and collaborative study to complete the final challenge during the training session. After the session, participants presented their Search and Rescue algorithms. The teachers rewarded assignment completion.

2.4. Data Collection and Analysis

The data was collected from the participants at the conclusion of the training session through the utilization of the Acceptance Scale of Mi-Robot [12] and an assessment form. The Acceptance Scale of Mi-Robot comprises four components: perceived utility, perceived ease of use, intention to use, and attitude. The scale accounted for 78.665% of the total variance, and the reliability coefficient (Cronbach's Alpha) was 0.956. A 5-point Likert-type scale has been developed to assess the degree of acceptance among pre-service instructors of Mi-Robot. The scale was employed to assess teachers' acceptance of the use of Mi-robot in the instruction of verbal and kinesthetic stimulation. Qualitative data were collected on the usability of Mi-Robot for teaching robotics programming. The evaluation form employed in this study comprised open-ended questions. The evaluation form comprises two distinct components. In the initial section of the form, participants were instructed to assess the utility, user-friendliness, attitude, and intention to use Mi-Robot content, including its modules and subjects. In the subsequent portion, the participants were requested to assess the usability of Mi-Robot.

The data collected from the participants was analyzed in accordance with the research problems. To address the initial research problem, we used data from participants' responses to the scale and the first section of the assessment form. The qualitative data collected from the second portion of the evaluation form were used to address the second research problem. The data collected from the scale were analyzed using descriptive statistics, while the data from the evaluation form were analyzed through content analysis. The individual responses to the assessment form were consolidated into a single file and subsequently imported into NVivo 10, a software tool for qualitative analysis. The data were read individually by researchers, and two distinct code lists were subsequently generated. Subsequently, the individuals collaborated on a comparative analysis of the codes, ultimately reaching consensus on a unified code list. The researchers imported the common code list into NVivo and independently coded the data in accordance with it. Cohen's Kappa reliability coefficient was computed to assess the level of agreement amongst the researchers, yielding a value of. 80 ($p < .05$). According to [13], this figure demonstrates a high level of agreement.

3. RESULT AND ANALYSIS

Table 2 presents the statistical data on teachers' responses to the Mi-Robot Acceptance Scale. According to the participants, Mi-Robot has the potential to be used for linguistic and kinesthetic stimulation, with a mean rating of 4.43 (SD = 1.21). The participants' perspectives on each aspect align well with the overall scale. The participants received the greatest mark in their attitude towards utilization. The findings of this study suggest that the participants hold a favorable attitude towards incorporating Mi-Robot into their future classroom activities. They perceive it as user-friendly and believe it may effectively enhance verbal and kinesthetic intelligence among children with special needs. In addition to the scale, the usability of Mi-Robot's content (including modules and subjects) was assessed by analyzing qualitative data obtained from the evaluation form.

Table 2. Pembagian data untuk Training dan Testing

Variable	Items	Mean ± SD
Perceived usefulness	4	4.43 ± 1.21
Perceived ease of use	4	4.15 ± 0.78
Attitude toward using in the future	5	4.52 ± 0.54
Behavioral intention to use	3	4.38 ± 0.57

Usefulness According to the teachers, the curriculum-aligned content of Mi-Robot is suitable for enhancing linguistic and kinesthetic intelligence in children with special needs. The included modules have been designed to accommodate individual learning differences and to connect with real-life experiences. The following are the teachers' perspectives on the utility of Mi-Robot. *The performance of Mi-Robot showed overall success. The arrangement of modules was found to be appropriate for promoting linguistic and kinesthetic intelligence in children with exceptional challenges." (Tn. A, 34 years old) "The Mi-Robot platform incorporates a curriculum that is tailored to the individual student's proficiency level, ensuring that the content is appropriate and aligned with their foundational knowledge." (Ny. L, 30 years old)*

The educators assessed the characteristics of the Mi-Robot modules to promote verbal and kinesthetic intelligence in children with exceptional needs. The subsequent section presents the study's outcomes and the participants' perspectives on the robotics content featured in Mi-Robot. Mi-Robot offers a diverse range of activities aimed at fostering linguistic and kinesthetic intelligence in children with exceptional needs. *"Given the abundance of activities and fictional elements present in the virtual environment, it would be more reasonable to express a preference for the Mi robot." (Ny. S, 35 years old). "The execution of numerous robotics programming tasks within a virtual environment can be facilitated by engaging in diverse challenges." (Tn. D, 31 years old).*

The functionality of Mi-Robot in promoting linguistic and kinesthetic intelligence for children with specific needs was assessed by the teachers. The subsequent section presents the study outcomes and participants' perspectives on the efficacy of the Mi-Robot."All functions in the Mi-Robot can be executed." (Tn G., 35 years old)

The content provided by Mi-Robot is vibrant and engaging, making it particularly appealing for student activities involving robots. "The design of the Mi-Robot exhibits a greater degree of color and entertainment." (Ny.G, 30 years old).

According to educators, the use of Mi-Robot to facilitate verbal and kinesthetic intelligence among children with special needs is considered a more cost-effective approach than relying solely on human resources. "In the event of financial insufficiency, the utilization of the Mi-Robot can serve as a viable solution for mitigating the drawbacks associated with the stimulation of linguistic and kinesthetic intelligence in children with exceptional needs". (Ny.Z, 32 years old).

3.1. DISCUSSION

This study aimed to assess the utility of Mi-Robot as a tool for enhancing linguistic and kinesthetic intelligence among children with special needs, as perceived by instructors. The study found that Mi-Robot is compatible with the curriculum used in school programming education, particularly in its module and subject structure. Consequently, educators expressed their intention to incorporate Mi-Robot into their instructional practices. According to previous research conducted by [14, 15], it has been found that Mi-Robot has the potential to be utilized as a tool for teaching robotics programming. These studies also considered educators' perspectives. According to [16], a significant portion of teachers' time is dedicated to assisting children in developing their linguistic and kinesthetic intelligences. Designing robots for a specific training purpose using physical robots is time-consuming. Furthermore, the presence of mechanical and technological challenges encountered during the process poses a significant hindrance for educators in effectively fostering linguistic and kinesthetic intelligence [17]. According to [18], Mi-Robot exhibits a high degree of modifiability, which contributes to the optimization of time utilization. This characteristic enables the seamless creation of learning activities, as highlighted by [16]. Furthermore, [16] emphasize that Mi-Robot facilitates prompt feedback from students regarding any challenges they may have experienced. Mi-Robot is designed to provide timely feedback to trainees when they encounter code errors. According to [16], the programme can be halted promptly in order to rectify any mistakes. Therefore, it can be argued that the utilization of Mi-Robot as a tool for enhancing verbal and kinesthetic intelligence in children with special needs holds potential for optimizing the efficient allocation of instructional time.

[17] underscored the need to provide instructors with a curriculum that promotes verbal and kinesthetic intelligence for children with exceptional needs, with the aim of preparing them for their future academic pursuits. According to this study's findings, educators reported that incorporating individual students' traits and real-life connections into activity design can enhance the development of verbal and kinesthetic intelligence. According to [19, 20], engaging in activities that utilize Mi-Robot for addressing everyday challenges might enhance students' critical thinking abilities. The inclusion of a robotics programming course in the Indonesian curriculum is noteworthy. Within the Mi-Robot system, several actions have been classified and organized according to the aforementioned categories. The exercises are organized sequentially, beginning with fundamental tasks, to facilitate the development of linguistic and kinesthetic intelligence. The difficulty level of the activities gradually increases as the learner progresses.

Mi-Robot awards badges to pupils upon successful completion of each challenge, incorporating gamification components inside its framework. The badges earned by students during activities can be accessed and seen on the network. Furthermore, educators can monitor students' progress and track their advancement by enrolling them in groups they have established within this network. According to [7], badges serve as indicators of students' development levels and serve as a means of encouraging their engagement in the learning process. According to this study's findings, educators reported that badges serve as a motivating factor for students to overcome assigned difficulties. Additionally, badges were noted to be effective tools for self-reinforcement.

Educators have a range of challenges when it comes to effectively using suitable media, designing the curriculum, and developing learning tasks that align with the proficiency level of students in recently incorporated courses, such as Mi-Robot [21]. The Mi-Robot is developed with a constructionist approach, allowing students to advance independently while receiving guidance from the teacher [18]. The use of graphical and icon-based coding interfaces in Mi-Robot enhances pupils' linguistic and kinesthetic proficiency. According to educators, the arrangement of challenges in Mi-Robot, starting with simpler tasks and progressing towards more complex ones, along with the use of a graphical, icon-based interface, can provide teachers with a curriculum that accommodates pupils' individual progress. This approach also facilitates easier practice for students.

The attitude of individuals towards adopting technology is influenced by their perception of its usefulness and simplicity of use [7]. Upon completion of the training programme, it was determined that educators had developed a favorable disposition toward the use of Mi-Robot. It is believed that incorporating Mi-Robot's features will increase students' interest and curiosity. The authors assert that the visual design of the virtual robot in Mi-Robot is noteworthy, as it is created to be compatible and elicit a favorable attitude among students. Furthermore, it was asserted that Mi-Robot exhibits numerous visually intricate designs, while the activity problems are artfully fictionalized to mirror real-life scenarios. According to [18], the inclusion of videos in Mi-Robot that establish connections between difficulties and real-life situations, while also providing hints for potential solutions, can serve as supplementary educational materials for teachers to effectively communicate the challenges to students at various proficiency levels.

The determination of individuals' desire to utilize technology is contingent upon their views and perceived utility, as evidenced by previous studies [7, 8]. In a study conducted by [18], it was noted that students who engaged in direct practice of complicated activities by dedicating more time to the use of Mi-Robot exhibited greater levels of interest and motivation. According to [18], the incorporation of modules in Mi-Robot has the potential to foster the cultivation of positive attitudes among students. This is achieved through a deliberate emphasis on the intricate three-dimensional visual design and its interconnection with everyday experiences. The affordability of the Mi-Robot contributes to an increased inclination among educators to include this platform within their instructional practices. The use of robotics teaching materials in educational institutions is contingent upon their affordability and accessibility for acquisition [18, 19]. Given the substantial student populations in classrooms and the inadequate resource allocation within educational institutions, we contend that employing Mi-Robot to foster verbal and kinesthetic intelligence would be a more favorable approach for children with special needs.

4. CONCLUSION

It has been determined that Mi-Robot has the potential to assist teachers in promoting linguistic and kinesthetic intelligence among children with special needs. This is due to the compatibility of its modules and subjects with linguistic and kinesthetic intelligence in educational settings. By using Mi-Robot, teachers can optimize their time and provide immediate feedback to students. Additionally, the incorporation of gamification elements encourages students to engage in learning. Furthermore, Mi-Robot's challenges can be tailored to reflect real-life situations, enhancing its relevance to daily life. According to the teachers, the incorporation of a visually appealing design and the compatibility of Mi-Robot are expected to enhance student engagement and foster curiosity.

The authors also emphasized that the use of Mi-Robot will significantly contribute to fostering a favorable disposition toward verbal and kinesthetic intellectual stimulation among children with special needs. The incorporation of Mi-Robot into their educational curriculum is motivated by its affordability and the opportunity it provides for pupils to engage in individualized practice.

In evaluating Mi-Robot's usability within the Technology Acceptance Model (TAM), teachers reported a positive perception of its potential utility and ease of use in activating verbal and kinesthetic intelligences. Consequently, the individuals cultivated a favorable disposition towards Mi-Robot and expressed their intention to include it into their forthcoming academic endeavors. Furthermore, it has been observed that the Acceptance Scale of Mi-Robot, originally designed to assess the acceptability of Mi-Robot, may also be employed to evaluate the acceptability of the Mi-Robot. In subsequent investigations, it is recommended that Mi-Robot be introduced to educators to assess the study's findings regarding its acceptance. Furthermore, it is suggested that teachers' views on the use of Mi-Robot be assessed using the Acceptance Scale. The future reaction to the present attitude and intention articulated by TAM may be compared. Future research could investigate the efficacy of Mi-Robot in facilitating linguistic and kinesthetic intelligence in remote education.

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The authors declare that no artificial intelligence tools were used in the design of the study, data collection, data analysis, interpretation of results, or manuscript preparation.

6. DECLARATIONS

AI USAGE STATMENT

During the preparation of this work, the author used ChatGPT (OpenAI) to improve the manuscript's language and clarity. Afterusing this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

AUTHOR CONTIBUTION

All authors contributed significantly to the writing of this article. They were actively involved in drafting and developing the content presented in the manuscript. In addition, all authors participated in revising and refining the article to ensure its clarity and accuracy.

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COMPETING INTEREST

The authors confirm that there are no conflicts of interest, either financial or non-financial, that could influence the research results and interpretation of the data in this article.

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