International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 2 (April-June 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I2.507

Development of Sensory-Rich Teaching Materials for Learners with Special Needs

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Publication history: Received: May 2, 2026; Revised: May 22, 2026; Accepted: May 27, 2026
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Abstract

This study focused on the development, validity, and acceptability of sensory-rich teaching materials for learners with special needs in inclusive educational settings in Aranyaprathet, Sa Keo Province, Thailand. Anchored on the ADDER Model, Multisensory Learning Theory, Sensory Integration Theory, and Constructivist Learning Theory, the study aimed to identify learners' sensory needs in terms of visual stimulation, auditory stimulation, tactile engagement, and kinesthetic activities and to develop instructional materials responsive to these needs. The study utilized descriptive-survey and Research and Development (R&D) methods. Respondents included selected special education and general education teachers, as well as evaluators composed of special education teachers, inclusive education teachers, and school administrators. Researcher-made questionnaire-checklists and evaluators' assessment checklists were used as instruments, while frequency counts, percentages, and means were employed in data analysis through SPSS. Findings revealed that learners with special needs demonstrated very high needs for visual, auditory, tactile, and kinesthetic sensory stimulation, with visual stimulation obtaining the highest overall mean. The developed sensory-rich teaching materials were evaluated as very highly valid in terms of content and pedagogical validity, sensory and instructional design, technical, physical and safety quality, and usability and contextual relevance. Likewise, the materials were rated very highly acceptable in terms of sensory modality, pedagogical efficacy and design, usability and safety, and learner engagement and affective response. The study concluded that sensory-rich instructional materials are highly appropriate for inclusive and special education settings because they support learner engagement, participation, accessibility, and multisensory learning experiences. The study recommended the wider utilization and validation of sensory-rich materials and encouraged future studies to determine their effectiveness in improving academic and developmental outcomes. The study supports Sustainable Development Goal (SDG) 4 on Quality Education by promoting inclusive and accessible learning opportunities for learners with special needs. It also aligns with SDG 10 on Reduced Inequalities through the promotion of equitable educational participation and inclusive instructional practices. The study contributes to educational and institutional sustainability by encouraging adaptive, learner-centered, and inclusive teaching approaches that improve long-term accessibility and participation in education. It also supports community sustainability by strengthening collaboration among teachers, schools, parents, and educational stakeholders in creating supportive learning environments for learners with special needs.

Keywords: Adder Model, Inclusive Education, Multisensory Learning, Sensory Integration, Sensory-Rich Materials, Special Needs, Tactile Engagement

1. Introduction

Inclusive education promotes equitable access to quality learning opportunities for all learners, including those with special needs. Despite global efforts toward educational inclusion, learners with disabilities continue to encounter barriers in traditional classroom environments because conventional instructional materials are commonly designed for neurotypical learners and often fail to address diverse sensory and cognitive needs. Research emphasizes that inclusive learning environments require adaptive, multisensory, and learner-centered instructional approaches to improve engagement, comprehension, participation, and academic achievement (UNESCO, 2023; CAST, 2024). Sensory-rich teaching materials support inclusive education by integrating visual, auditory, tactile, and kinesthetic elements that stimulate multiple sensory pathways. These materials align with the Universal Design for Learning framework by providing multiple means of representation, engagement, and expression, thereby improving accessibility and reducing barriers to learning (CAST, 2024). Studies indicate that multisensory instructional strategies enhance attention, memory retention, adaptive behavior, and concept understanding among learners with special educational needs (Al-Azawei et al., 2024; De Domenico et al., 2024; Gulati et al., 2024; Wen & Wu, 2025). However, educational institutions, particularly in developing contexts, continue to face challenges in implementing sensory-rich instructional practices because of inadequate resources,

insufficient teacher training, limited technological support, and lack of localized research on contextually relevant teaching materials (Masri & Zulkipli, 2025). In Thailand, inclusive education policies encourage the integration of learners with special needs into mainstream classrooms, yet many schools still rely heavily on traditional instructional methods that do not adequately support multisensory learning. In response to these concerns, this study focuses on the development, validity, and acceptability of sensory-rich teaching materials for learners with special needs. Specifically, the study examines learners' sensory needs in terms of visual stimulation, auditory stimulation, tactile engagement, and kinesthetic activities, while also evaluating the instructional quality, usability, and relevance of the developed materials.

1.1 Background of the Study on Sensory-Rich Teaching Materials for Learners with Special Needs

Inclusive education recognizes the right of all learners to access quality education regardless of disability or background. However, learners with special needs often experience physical, instructional, and social barriers in mainstream educational settings because traditional teaching materials are generally designed for neurotypical learners. These materials frequently lack the multisensory features necessary to support learners with sensory, cognitive, and developmental disabilities. Recent studies emphasize that inclusive instruction requires adaptive and flexible learning approaches that accommodate varied learner abilities and promote meaningful participation in classroom activities (UNESCO, 2023). The Universal Design for Learning framework supports this principle by advocating multiple means of representation, engagement, and expression to improve accessibility and educational outcomes (CAST, 2024). Flexible and sensory-inclusive learning environments have been shown to increase learner engagement and reduce exclusion among students with disabilities (Florian & Beaton, 2023). Sensory-rich teaching materials integrate textures, sounds, colors, movement, and interactive components to stimulate multiple senses and improve comprehension. Research demonstrates that multisensory instructional approaches improve attention, memory retention, engagement, and adaptive behaviors among learners with special educational needs (Al-Azawei et al., 2024; De Domenico et al., 2024). Likewise, tactile and kinesthetic learning activities significantly enhance cognitive development and understanding among learners with developmental disorders (Javed et al., 2025). Studies also indicate that combining auditory, visual, and tactile stimuli creates richer learning experiences that strengthen comprehension and retention (Frontiers in Education, 2024). Despite these benefits, many schools in developing regions continue to experience limited access to sensory-based instructional materials because of inadequate funding, insufficient teacher preparation, and lack of specialized resources (Masri & Zulkipli, 2025). Limited localized research further constrains the development of culturally relevant and cost-effective multisensory materials suited to existing curricula and learner contexts. Consequently, there is a growing need to develop innovative and accessible sensory-rich teaching materials that support inclusive educational practices and improve learning outcomes for learners with special needs.

1.2 Themes and Insights from Related Literature on Multisensory Learning and Inclusive Education

Related literature consistently emphasizes the importance of sensory integration and multisensory instruction in special education. Sensory processing refers to the brain's ability to receive, organize, and interpret sensory information to support meaningful behavior and learning (Kid Sense, 2024). Difficulties in sensory processing may negatively affect attention, emotional regulation, participation, and academic performance among learners with neurodevelopmental conditions (Connect, n.d.). Studies show that learners with Autism Spectrum Disorder and Attention Deficit Hyperactivity Disorder commonly exhibit atypical sensory processing patterns associated with lower academic achievement, thereby highlighting the need for sensory-responsive instructional materials (Li et al., 2025). Sensory materials such as playdough, sand, sensory bins, textured objects, and interactive toys stimulate multiple senses and promote exploration, fine motor development, language acquisition, cognitive growth, and social interaction (Big Blue Marble Academy, 2025; Jordan, 2025; Kanor, 2022). Multisensory pedagogy involves the simultaneous engagement of visual, auditory, tactile, and kinesthetic senses to enhance learning, comprehension, and long-term retention. Research indicates that multisensory teaching improves focus, participation, memory, motivation, and confidence, especially among learners with dyslexia, dysgraphia, dyscalculia, and other learning difficulties (Morin, n.d.; Kool Minds Team, 2022; Kumar, 2026). Multisensory strategies also make abstract concepts more concrete and accessible through hands-on and interactive learning experiences. However, literature likewise identifies major barriers to implementing sensory-rich instruction. These include lack of funding, insufficient sensory materials, limited teacher expertise, large class sizes, inadequate classroom design, and weak administrative support (Kurowski et al., 2022; Masri & Zulkipli, 2025; Beck et al., 2021; Alsolami & Vaughan, 2023). Teachers also experience difficulties evaluating the effectiveness of sensory-based interventions because of the absence of standardized assessment tools and implementation guidelines (Dynia et al., 2022; Gunderson et al., 2023). Instructional development models such as ADDIE, Dick and Carey, and the Kemp Model provide systematic frameworks for designing, implementing, evaluating, and revising instructional materials. These models emphasize learner analysis, instructional alignment, formative evaluation, and continuous improvement, making them appropriate for the development of sensory-rich teaching materials (Lasky, 2024; Instructional Design Central, 2025; Digital Learning Institute, 2025).

1.3 Local, National, and Global Context of Inclusive and Sensory-Based Education

Globally, inclusive education remains a major educational priority supported by organizations such as UNESCO and the United Nations through Sustainable Development Goal 4, which advocates inclusive and equitable quality education for all learners. Although many countries have implemented inclusive education policies, learners with disabilities still face

barriers because traditional instructional methods commonly prioritize visual and auditory instruction while neglecting multisensory learning needs. In Thailand, the Ministry of Education promotes inclusive education through reforms that support the integration of learners with special needs into mainstream schools. Despite these efforts, teachers often lack adequate training and access to sensory-based instructional resources, resulting in continued reliance on traditional teaching methods that may not effectively address diverse sensory and cognitive needs. Historically, sensory-based learning approaches have been strongly influenced by Maria Montessori's educational philosophy, which emphasizes hands-on learning and structured sensory experiences. Montessori's sensorial materials were designed to improve concentration, independence, and cognitive development through tactile, auditory, and visual exploration. Contemporary special education research continues to support these principles by emphasizing the importance of multisensory instruction in improving learner participation, attention, and behavior.

1.4 Theoretical and Conceptual Basis for the Development of Sensory-Rich Teaching Materials

This study is anchored on the ADDER Model, a modified instructional design framework derived from ADDIE. The model emphasizes systematic processes of analysis, design, development, evaluation, and revision to ensure the continuous improvement of instructional materials. In this study, the model guides the identification of learners' sensory needs, the development of multisensory instructional resources, and the validation and revision of the materials based on expert evaluation. The study is further supported by the Multisensory Learning Theory, which proposes that learners understand concepts more effectively when multiple senses are simultaneously engaged. This theory supports the use of sensory-rich teaching materials that incorporate visual, auditory, tactile, and kinesthetic activities for learners with special needs. Sensory Integration Theory also underpins the study by explaining how learners process and respond to sensory stimuli. Learners with special needs may experience challenges organizing sensory information, affecting their behavior and learning performance. Structured sensory-rich instructional materials can therefore improve learners' ability to process environmental stimuli and participate effectively in educational settings. Additionally, Constructivist Learning Theory supports the study by emphasizing that knowledge is actively constructed through experience and interaction. Sensory-rich teaching materials provide opportunities for learners to explore, manipulate, and engage with content directly, thereby promoting deeper understanding and meaningful learning experiences.

1.5 Research Gaps and Rationale for Developing Sensory-Rich Teaching Materials

Previous studies primarily focused on determining the effectiveness of multisensory instructional materials in improving competencies across various learning areas (Bitong & Chua, 2024; Juwita et al., 2018; Sia, 2025). Other investigations examined teacher perceptions, implementation challenges, and the role of sensory-based instruction in supporting cognitive and socioemotional development (Masri & Zulkipli, 2025; Amiruddin et al., 2025). Although studies by Ambas and Feliciano (2025) and Juwita et al. (2018) involved the development of multisensory instructional materials, limited research specifically addresses the systematic development of sensory-rich teaching materials tailored for learners with special needs in inclusive educational settings. Existing studies also provide limited emphasis on identifying learners' sensory needs prior to material development. This study addresses these gaps by first examining the visual, auditory, tactile, and kinesthetic needs of learners with special needs before developing and validating sensory-rich teaching materials. The study also contributes localized and contextually relevant instructional resources for inclusive classrooms in Thailand.

1.6 Alignment with Relevant Sustainable Development Goals (SDGs)

This study aligns primarily with SDG 4 – Quality Education because it promotes inclusive, equitable, and accessible learning opportunities for learners with special needs through the development of sensory-rich instructional materials. By supporting individualized and multisensory learning approaches, the study contributes to improving educational participation, learner engagement, and academic accessibility. The study also supports SDG 10 – Reduced Inequalities by addressing barriers experienced by learners with disabilities in mainstream educational settings. Through inclusive instructional practices, the research promotes equal educational opportunities and learner participation. Additionally, the study contributes to SDG 3 – Good Health and Well-Being by supporting learners' emotional regulation, behavioral development, and overall well-being through sensory-responsive learning environments.

1.7 Importance of the Study to Multidisciplinary Sustainability

This study contributes to educational sustainability by promoting inclusive instructional practices that accommodate diverse learner needs and improve long-term accessibility in education systems. The development of sensory-rich teaching materials supports sustainable teaching approaches that enhance learner participation, comprehension, and retention. The study also contributes to socio-economic sustainability by improving educational equity for learners with special needs, thereby supporting their long-term academic and social development. Through improved instructional accessibility, the research may help reduce educational exclusion and strengthen inclusive community participation. In terms of technological and innovation sustainability, the study encourages the development of adaptive and multisensory educational resources that can support future innovations in special education. Furthermore, the study promotes institutional sustainability by providing educators, school administrators, and curriculum planners with evidence-based insights for strengthening inclusive education policies, instructional design, and teacher professional development. Finally,

the study contributes to community sustainability by fostering collaborative involvement among teachers, parents, schools, and educational stakeholders in creating supportive and inclusive learning environments for learners with special needs.

2. Material and methods

2.1 Research Design

The study utilized the descriptive-survey and Research and Development (R&D) methods, also known as the Research-Based Development Methodology. The descriptive-survey design was used to determine the learning and sensory needs of learners with special needs in terms of visual stimulation, auditory stimulation, tactile engagement, and kinesthetic activities. Meanwhile, the R&D method guided the development of sensory-rich teaching materials. According to Amiruddin (2025), the Research and Development method involves a systematic process of assessing needs, designing materials, developing prototypes, implementing them, and evaluating their effectiveness. However, the study focused only on developing the sensory-rich teaching materials and determining their validity and acceptability.

2.2 Locale of the Study

The study was conducted in selected public and private elementary schools in Aranyaprathet, Sa Keo Province, Thailand. These schools included institutions implementing inclusive education programs for learners with special needs.

2.3 Respondents of the Study

The respondents of the study included selected special education and general education teachers from public and private elementary schools, as well as a pool of evaluators who assessed the validity and acceptability of the developed sensory-rich teaching materials. The evaluators consisted of four special education teachers, three elementary teachers handling inclusive education classes with at least three years of experience teaching learners with special needs, and three school administrators managing schools that implement inclusive education in Thailand.

2.4 Sample and Sampling Procedure

The study employed convenience sampling in selecting the teacher-respondents. Convenience sampling, as defined by Nikolopoulou (2023), is a non-probability sampling method in which participants are selected based on accessibility, availability, and proximity. The respondents were selected because they were readily accessible to the researcher.

2.5 Research Instrument

The study utilized two researcher-made instruments. The first was a Five-Point Likert-type questionnaire-checklist used to determine the learning and sensory needs of learners with special needs. The second instrument was an Evaluators' Assessment Checklist used to determine the validity and acceptability of the developed sensory-rich teaching materials. The indicators and categories included in the checklist were derived from related literature and studies. To establish content validity, the instruments were reviewed by the researcher's adviser and critic-reader. After incorporating their comments and suggestions, the instruments were submitted to a panel of evaluators for content validation. The instrument was considered valid when it obtained an average rating of at least 3.50. The instrument achieved an average rating of 4.56, indicating that it was highly valid. The development of the sensory-rich teaching materials underwent four phases: analysis, design, development, and validation. During the analysis phase, the researcher administered the questionnaire-checklist to determine the learning and sensory needs of learners with special needs and reviewed existing instructional materials used in special and inclusive education classes. Consultations were also conducted with the adviser, critic-reader, special and inclusive education teachers, and MAED-SPED professors of PSU-SAS regarding the development of the materials. Related literature and studies were likewise considered in developing the teaching materials. The researcher also analyzed available materials to formulate guidelines regarding format, technical details, presentation techniques, and graphics such as illustrations, diagrams, charts, graphs, maps, and photographs. During the design phase, the researcher identified the learning objectives and determined the sensory elements appropriate for the learning content. The researcher prepared the conceptual framework, pedagogical strategies, and sequencing of activities. Storyboards and flowcharts were also designed to visualize the sequence of sensory inputs and learner actions. Tactile elements, sound, movement, high-contrast visuals, large text, and clear layouts following Universal Design for Learning principles were incorporated into the materials. The researcher selected appropriate physical and digital resources while ensuring safety, durability, and non-toxicity of the materials. Assessment strategies were likewise integrated to allow learners to demonstrate competence through sensory-rich and interactive tasks. Environmental factors such as lighting, background noise, and classroom distractions were also considered to ensure that the materials would effectively support learning. During the development phase, the researcher prepared the first draft of the sensory-rich teaching materials after reviewing instructional materials used for learners with special needs. The draft was evaluated by the adviser, critic-reader, and a special education teacher who were not part of the validation stage. Their comments and suggestions were incorporated into the second draft. In the validation phase, the second draft of the materials was evaluated by a panel composed of special education teachers, inclusive education teachers, and school administrators. The evaluators used the researcher-made assessment checklist to determine the validity and acceptability of the developed sensory-rich teaching materials. Their comments and recommendations served as the basis

for further revisions and for the preparation of the final version of the workbook. The development process emphasized identifying learners' sensory and learning needs, designing appropriate sensory-based instructional strategies, integrating tactile and interactive activities, and validating the materials through expert evaluation. The procedures ensured that the developed sensory-rich teaching materials were educationally relevant, safe, learner-centered, and suitable for inclusive education settings.

2.6 Data Gathering Procedure

The data gathering procedure followed a systematic and ethical process. The researcher first secured approval from the Executive Director of the PSU–School of Advanced Studies to conduct the study in Thailand. Upon approval, letters requesting permission were sent to school directors to allow the conduct of the survey among teachers in their respective schools. After approval was obtained, the researcher met with the selected teachers and evaluators to explain the purpose of the study, answer questions and concerns, and emphasize that participation would be voluntary. Informed consent forms outlining the objectives of the study, participants' rights, confidentiality, anonymity, and voluntary participation were distributed. Only respondents who signed and returned the informed consent forms were included in the study. The questionnaire-checklist used to determine the learning and sensory needs of learners with special needs was administered personally or through Google Docs. The Evaluators' Assessment Checklist used to assess the validity and acceptability of the sensory-rich teaching materials was administered personally by the researcher while presenting the developed materials to the evaluators. The gathered data served as the basis for determining the validity and acceptability of the developed teaching materials.

2.7 Data Analysis Techniques

The data gathered were analyzed with the assistance of the PSU–School of Advanced Studies Statistics Center using the Statistical Package for Social Sciences (SPSS). Frequency counts and means were used to analyze the learning and sensory needs of learners with special needs in terms of visual, auditory, tactile, and kinesthetic stimulation. The level of validity of the developed sensory-rich teaching materials in terms of content and pedagogical validity, sensory and instructional design, technical, physical and safety quality, and usability and contextual relevance was analyzed using frequency counts, percentages, and means. Mean ranges were interpreted using verbal descriptions from Strongly Disagree/Not Valid to Strongly Agree/Highly Valid. The level of acceptability of the sensory-rich teaching materials in terms of sensory modality, pedagogical efficacy and design, usability and safety, and learner engagement and affective response was also analyzed using frequency counts, percentages, and means. Mean scores were interpreted using verbal descriptions ranging from Strongly Disagree/Not Valid to Strongly Agree/Highly Acceptable.

2.8 Ethical Considerations

The study strictly adhered to ethical standards to protect the rights and welfare of all participants. Respondents were informed about the nature, objectives, and procedures of the study, including their right to refuse participation or withdraw at any time without penalty. Written informed consent was obtained from all participants. Confidentiality and anonymity were ensured by excluding personal identifying information from the questionnaires and by reporting responses only in aggregate form. Participation was entirely voluntary, and respondents were assured that their decision to participate or not would not affect their employment or professional standing. The study aimed to contribute positively to the educational community while ensuring that no physical, psychological, or social harm would come to participants. Furthermore, the research process and findings were presented honestly and transparently without misrepresentation of data.

3. Results and Discussion

3.1 Learning and Sensory Needs of Learners with Special Needs

3.1.1 Visual Stimulation Needs

The findings revealed that learners with special needs demonstrated a very high need for visual stimulation materials, with an overall mean of 4.606. The categories of light and illumination, high-contrast and color tools, visual tracking and movement aids, tactile-visual materials, and adapted print and cognitive materials were all rated as very highly needed. Among the materials, light tables or boxes and light learning rocks obtained the highest means of 4.94, while visual sensory bottles and spinning mobiles also received very high ratings. Large-print and high-contrast worksheets and visual schedules were likewise perceived as very highly needed. Only a few materials, such as gel bags, textured graphics, and Picture Exchange Systems (PECS), were rated as highly needed rather than very highly needed. These findings suggest that visual stimulation is essential for improving educational access, engagement, and learning performance among learners with special needs. The results imply that existing instructional approaches may lack sufficient visual supports needed by these learners. The findings support the Sensory Integration Theory, which explains that sensory materials help learners organize and interpret visual information more effectively, thereby improving learning and functional performance. The findings are also aligned with the Sensory Stimulation Theory, which emphasizes that visual input plays a major role in learning and memory retention.

3.1.2 Auditory Stimulation Needs

The findings showed that auditory stimulation materials were perceived as very highly needed, obtaining an overall mean of 4.593. Musical instruments and sound makers, technology and listening devices, and environmental and calming auditory tools all received very high ratings from the respondents. Adapted music kits obtained the highest mean of 4.96, followed by audiobooks and listening stations with a mean of 4.84 and white noise or nature sound machines with a mean of 4.78. Most auditory materials were rated very highly needed, while Boomwhackers, sound-activated equipment, water play items, and voice modulators were rated highly needed. The results indicate that auditory stimulation materials are essential for supporting learners with special needs in improving attention, behavioral regulation, and learning performance. The findings support the Sensory Integration Theory, which explains that learners with sensory processing difficulties often struggle to filter and organize auditory input. Auditory tools such as sound-dampening devices, sound-producing materials, and calming auditory resources help regulate sensory stimulation and improve learners' ability to respond effectively to their environment.

3.1.3 Tactile Engagement Needs

The findings revealed that tactile engagement materials were also perceived as very highly needed, with an overall mean of 4.570. Under manipulatives and fine motor tools, playdough, therapy putty, sensory balls, lacing cards, and fidget tools were rated very highly needed, while weighted items were rated highly needed. In the category of sensory bins and messy play materials, dry fillers and hair gel bags obtained very high ratings, whereas kinetic sand, water beads, and shaving cream were rated highly needed. These findings indicate the importance of tactile materials in supporting neurological organization, attention, and behavioral regulation among learners with special needs. The findings are consistent with the Sensory Integration Theory, which emphasizes that tactile input helps learners process sensory information more effectively. Tactile materials such as textured objects, putty, and sensory bins support both hypersensitive and hyposensitive learners by improving focus, reducing stress, and promoting adaptive responses to environmental stimuli.

3.1.4 Kinesthetic Activity Needs

The findings showed that kinesthetic activity materials were perceived as very highly needed, obtaining an overall mean of 4.572. Tactile manipulatives, movement-based tools, tactile writing and drawing surfaces, and interactive and functional tools all received high ratings. Playdough, active seating tools, bouncy bands, salt or sand trays, raised-line paper, fidget toys, and chewable jewelry were rated very highly needed. Meanwhile, tactile letter cards, mini trampolines, Velcro or snap activities, and large beach balls were rated highly needed. The findings suggest that kinesthetic materials are essential in supporting motor development, self-regulation, body awareness, and focus among learners with special needs. The results are explained by the Sensory Integration Theory, which highlights the importance of proprioceptive and vestibular sensory systems in improving motor planning and behavioral regulation. Kinesthetic activities such as movement-based learning and sensory tools provide the sensory input needed to organize the nervous system and support active learning.

3.1.5 Overall Learning and Sensory Needs

The summary findings indicated that all categories of learning and sensory needs were perceived as very highly needed, with an overall mean of 4.585. Visual stimulation obtained the highest mean of 4.606, followed by auditory stimulation at 4.593, kinesthetic activities at 4.572, and tactile engagement at 4.570. These results emphasize the urgent need for teachers and parents to provide sensory-rich instructional materials for learners with special needs. The findings reinforce the Sensory Integration Theory, which explains that sensory-rich tools and materials help learners improve learning, behavioral regulation, and overall development by supporting the organization and interpretation of sensory information.

3.2 Validity of the Developed Sensory-Rich Teaching Materials

3.2.1 Content and Pedagogical Validity

The findings showed that the developed sensory-rich teaching materials were evaluated as very highly valid in terms of content and pedagogical validity, with a sub-mean of 4.70. The indicators "Sensory input matches the learners' developmental stage" and "The materials promote active engagement, critical thinking, and exploration" obtained the highest means of 4.90. The indicator on curriculum alignment obtained a mean of 4.60, while the accuracy and authenticity of information obtained the lowest mean of 4.40 but remained highly valid. The findings indicate that the developed materials effectively support curriculum goals and learner development while encouraging active participation and exploration. The results suggest that the materials are developmentally appropriate and capable of promoting meaningful multisensory learning experiences among learners with special needs.

3.2.2 Sensory and Instructional Design Validity

The developed materials were also rated very highly valid in terms of sensory and instructional design, obtaining a sub-mean of 4.85. The indicators related to clear and recognizable visuals and tactile elements, as well as the ability of the materials to maintain learner attention and curiosity, obtained the highest means of 4.90. The indicators on engaging

multiple sensory pathways and providing immediate feedback both received means of 4.80. These findings suggest that the materials effectively integrate multisensory instructional principles that enhance learner engagement, understanding, and self-monitoring. The results indicate that the materials successfully combine visual, tactile, and auditory components to support meaningful learning experiences.

3.2.3 Technical, Physical, and Safety Quality

The findings revealed that the developed materials were very highly valid in terms of technical, physical, and safety quality, with a sub-mean of 4.65. The highest-rated indicator was the safety and non-toxicity of the materials, which obtained a mean of 4.80. The durability and appropriateness of the materials' size and weight also received high ratings, while organization and ease of navigation obtained a mean of 4.50 and were interpreted as highly valid. These findings indicate that the developed sensory-rich materials are safe, durable, and appropriate for repeated classroom use by learners with special needs. The results further suggest that the materials were designed with consideration for learners' physical capabilities and classroom practicality.

3.2.4 Usability and Contextual Relevance

The materials were evaluated as very highly valid in terms of usability and contextual relevance, obtaining a sub-mean of 4.85. The indicator on versatility for different topics and proficiency levels obtained the highest mean of 5.00. Accessibility and language appropriateness also received very high ratings, while clarity of directions obtained the lowest mean of 4.60. The findings imply that the developed materials are adaptable, accessible, and suitable for diverse instructional contexts and learner abilities. The results further indicate that the materials can effectively support inclusive educational practices while remaining practical for classroom implementation.

3.2.5 Overall Validity of the Developed Materials

Overall, the developed sensory-rich teaching materials were rated as very highly valid, obtaining an overall mean of 4.76. The findings demonstrate that the developed instructional materials effectively met the standards for content quality, instructional design, safety, usability, and contextual relevance. The results confirm that the materials are appropriate for supporting multisensory and inclusive learning experiences for learners with special needs.

3.3 Acceptability of the Developed Sensory-Rich Teaching Materials

3.3.1 Sensory Modality Acceptability

The findings showed that the developed sensory-rich teaching materials were very highly acceptable in terms of sensory modality, obtaining a mean of 4.68. Attractive visuals, varied textures, and appropriate sound production received high ratings. The indicator on varied tactile textures obtained the highest mean of 4.90, while the indicator on pleasant aromas obtained the lowest mean of 4.40 but remained highly acceptable. These findings suggest that the developed materials effectively stimulate multiple sensory modalities and provide meaningful sensory experiences that support learner attention, comprehension, and engagement. The results indicate that the materials successfully integrate visual, tactile, auditory, and sensory components appropriate for learners with special needs.

3.3.2 Pedagogical Efficacy and Design Acceptability

The materials were rated very highly acceptable in terms of pedagogical efficacy and design, obtaining a mean of 4.84. The indicators on transforming abstract concepts into tangible experiences, promoting self-correction, increasing learner interest, and encouraging critical thinking all obtained means of 4.90. The indicator on supporting learning objectives obtained the lowest mean of 4.60. The findings imply that the developed materials effectively support instructional objectives and active learning among learners with special needs. The results further suggest that the materials encourage independent learning, engagement, and higher-order thinking skills through multisensory instructional strategies.

3.3.3 Usability and Safety Acceptability

The findings revealed that the materials were very highly acceptable in terms of usability and safety, with a sub-mean of 4.83. Safety, durability, developmental appropriateness, and proper formatting all received very high ratings. The indicators on safety and developmental appropriateness both obtained the highest mean of 4.90, while affordability obtained the lowest mean of 4.70. These findings indicate that the materials are safe, practical, and suitable for repeated use in inclusive educational settings. The results also suggest that the materials were carefully designed to match learners' developmental levels, motor skills, and classroom needs.

3.3.4 Learner Engagement and Affective Response

The findings showed that the developed materials were very highly acceptable in terms of learner engagement and affective response, obtaining a sub-mean of 4.90. All indicators, including enjoyment of sensory experiences, active manipulation, sustained engagement, and emotional stimulation, received identical means of 4.90. The findings suggest that the sensory-

rich teaching materials effectively promote learner participation, attention, enjoyment, and emotional engagement. The results indicate that the materials are capable of sustaining learners' interest and supporting positive learning experiences for learners with special needs.

3.3.5 Overall Acceptability of the Developed Materials

Overall, the developed sensory-rich teaching materials were rated very highly acceptable, obtaining an overall mean of 4.81. These findings confirm that the developed sensory-rich teaching materials are highly appropriate for use among learners with special needs. The results demonstrate that the materials effectively satisfy standards related to sensory modality, instructional design, usability, safety, and learner engagement, thereby supporting inclusive and multisensory educational practices.

4. Conclusion and Recommendations

The study concluded that sensory-rich teaching materials incorporating visual, auditory, tactile, and kinesthetic components are very highly needed for learners with special needs. The developed sensory-rich teaching materials were found to be very highly valid in terms of content and pedagogical validity, sensory and instructional design, technical, physical, and safety quality, and usability and contextual relevance. Furthermore, the materials were evaluated as very highly acceptable in terms of sensory modality, pedagogical efficacy and design, usability and safety, and learner engagement and affective response, indicating their appropriateness for use in inclusive and special education settings.

The developed sensory-rich teaching materials may be shared with teachers handling learners with special needs and those teaching in inclusive education settings to support multisensory instruction. Future studies may be conducted to determine the effectiveness of the developed sensory-rich materials in enhancing the capacities and learning outcomes of learners with special needs. School heads may also encourage teachers to develop additional sensory-rich instructional materials for diverse learners and submit these materials for validation to ensure quality and appropriateness for classroom use.

The study was limited to the development, validity, and acceptability of sensory-rich teaching materials for learners with special needs and did not include the determination of their effectiveness in improving learners' academic performance or developmental outcomes. The respondents were limited to selected teachers and evaluators from public and private elementary schools in Aranyaprathet, Sa Keo Province, Thailand, which may limit the generalizability of the findings to other educational settings or populations.

Compliance with ethical standards

The authors declare no conflict of interest. This study received no external funding and was conducted with the approval and cooperation of the PSU–School of Advanced Studies and selected public and private elementary schools in Aranyaprathet, Sa Keo Province, Thailand. Participation in the study was voluntary, and informed consent was obtained from all teacher-respondents prior to data collection through non-invasive survey questionnaires and evaluation checklists. All responses were treated with strict confidentiality, and no identifying personal information was disclosed in any part of the study.

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