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Development of sensory-based inclusive vocational modules in graphic design: a case study of neurodivergent learners in a vocational training institution

Anne Nurfarina [a,1 *], Firli Herdiana [b,2],

[a] Universitas Multimedia Nusantara, Jl Scientia Boulevard, Tangerang 15810, Indonesia
[b] LPK ATC Widyatama, Jl Cikutra 204 A, Bandung 40124, Indonesia
[1] anne.nurfarina@umn.ac.id*; [2] firliherdianamail@gmail.com;
* Corresponding Author

ABSTRACT

The purpose of this study is to develop a sensor-based vocational learning module that is appropriate for neurodivergent individuals, such as those with autism, as well as those who are enrolled in the LPK ATC Widyatama Program Desain Grafis. This module integrates sensor-based learning strategies and natural stimulation to increase students' understanding and engagement. Drawing from Ayres' theory of sensor integration, Vygotsky's theory of sociocultural education, and TPACK's work ethics, this module aims to improve cognitive, affective, and psychomotor learning. This study employs a qualitative case study methodology based on Design Thinking principles, which helps students understand the learning context. Interviews, artifact analysis, and observation are used to assess the learning process and results. The study's findings indicate that individualized sensory stimulation, such as visual references from movies, television shows, and video games, helps consumers develop ideas into products' graphic design. Among the things that are discussed are individual accommodations and the improvement of the instructional environment. This study offers a starting point for vocational education with recommendations for more comprehensive sensor integration.

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1. Introduction

Vocational education for neurodivergent individuals serves not only as a pathway to acquiring job skills but also has the strategic advantage of fostering self-awareness [1]. Through a practical, concrete, and structured learning approach, individuals with different ways of thinking can directly explore their potential in a supportive and focused environment [2]. This process allows them to identify their strengths, interests, and learning styles that best suit their neurological characteristics [3]. Success achieved in vocational practice activities also strengthens self-confidence and personal identity, which are often major challenges for neurodivergent individuals in conventional education systems [4]. Thus, vocational education plays a crucial role not only in economic empowerment but also in identity formation and improving overall quality of life [5]. In Indonesia, the opportunities for vocational training that are tailored to each neurodivergent person's sensory and cognitive needs are still quite limited. According to LPK ATC Widyatama in Bandung, West Java, a creative education organization in Bandung, the number of new hires decreased by 23% in 2021 compared to 2019 as a result of the COVID-19 pandemic (internal report ATC, 2022). The phenomenon of the growing awareness of diverse learning styles, particularly among neurodivergent individuals [2], [6]–[8], has prompted an urgent need for learning modules that are more adaptive and responsive to their unique needs.

One relevant approach is the use of intuitive sensory-based modules, a learning strategy that relies on sensory experiences and understanding that develop naturally through exploration, rather than solely through verbal instructions or abstract theories [9]. Neurodivergent individuals, such as those on the autism spectrum or with ADHD, tend to exhibit more positive learning responses to visual, auditory, kinesthetic, or tactile stimuli, making learning more effective when tailored to their sensory strengths [10]. In this context, Lev Vygotsky's sociocultural theory provides a solid conceptual foundation, emphasizing the importance of social interaction, the role of culture, and environmental support (scaffolding) in developing an individual's learning potential [11]. By using this theory as a framework, educational approaches can be designed to be more inclusive, meaningful, and capable of optimally fostering the cognitive development and self-awareness of neurodivergent individuals. According to Vygotsky, social and environmental interactions play a vital role in cognitive development [12]. The concept of the Zone of Proximal Development (ZPD) suggests that individuals can achieve their highest learning potential through guidance from more experienced peers or mentors [13]. In a vocational context, this can be applied through project-based learning [14], collaborative group activities [15], and scaffolding techniques that support learning through meaningful interactions [16]. Scaffolding is a teaching strategy designed to assist students in understanding new concepts in an engaging way while progressively enhancing their competence. However, the majority of the vocational training curricula now in use are very uniform and do not take into account the needs of the senses, learning styles, and neurodivergent individuals' capacity for adaptation [17], [18].

The main challenges in developing the curriculum for this group include difficulty understanding spoken instructions, difficulty understanding visual instructions, and difficulty developing social skills [19]. Because of this, curriculum design that emphasizes multisensory learning is essential to ensuring student satisfaction and learning effectiveness [20], [21]. According to Leinfuss *et al*. [22], sensory-based modules assist neurodivergent learners in improving their focus, understanding abstract concepts in a concrete way, and creating each material link through silent investigation. Interactive movies, visual media, and even augmented reality (AR) are examples of technology that can enhance learning outcomes and boost practical abilities [23] The Universal Design for Learning (UDL) principle, which promotes adaptable, customized, and accountable learning in respect to students' requirements, is also rigorously followed in the development of this module [24]. Accordingly, developing a sensor-based vocational education module for neurodivergent individuals is an innovative approach that not only improves learning effectiveness but also fosters social awareness and work ethic. This study aims to evaluate, implement, and assess a sensor-based design module in graphic design education at LPK ATC Widyatama by focusing on industry relevance and increasing student capacity in a comprehensive manner. Based on the aforementioned background, the purpose of this study is to assess the effectiveness of a sensor-based vocational education module and to enhance the process of neurodivergent individual learning in the graphic design of LPK ATC Widyatama. This module aims to address social interaction, sensory responsiveness, and the relationship between existing teaching methods and students' needs. The main focus of this module's development is on multisensory development that is applicable in a practical way and supported by Vygotsky's sociocultural theory in a vocational context. The primary contribution of this research is in the methodology and practice of vocational inclusive education, which is the development of sensor-based learning strategies that are validated and tailored to the characteristics and preferences of neurodivergent learners. By incorporating the Universal Design for Learning (UDL) principles, the Zona Development of Proximal (ZDP) theory, and contextual learning, it is hoped that this approach will not only increase learning effectiveness but also create a model of instruction that other organizations can use with similar characteristics.

2. Methods

This study uses a qualitative approach with a case study strategy for six students who are systematically combined with the Design Thinking for Education (DTE) approach. This strategy aims to support the development of a sensor-based vocational learning module for neurodivergent communities at LPK ATC Widyatama, specifically in the context of graphic

design training. The Case study approach provides exploratory insight into understanding the dynamics, needs, and challenges faced by mental, intellectual, and physical disabilities, as well as obstacles in the vocational training process [25]. This case study focuses on real-world situations and aims to understand contextual understanding from all available perspectives, including student learning, structure, and module development. On the other side, Design Thinking for Education is being used as an innovative work tool to develop responsive educational solutions for users' needs. This pedagogy is very relevant to the context of inclusive education since it emphasizes patience, teamwork, and iteration in the learning process [26]. As a result, Design Thinking is not positioned as the most effective method; rather, it is shown as an essential component of the development strategy in this case study. The two approaches' integration is shown as follows: (1) Analyses of case studies provide context, qualitative data, and analysis of real-world situations, (2) In the process of developing solutions, Design Thinking is used through the following phases, which are carried out in an iterative manner: Empathize, Define, Ideate, Prototype, and Test. Graphic design learners and instructors are the primary participants in this stage, which is carried out through a participatory approach. Data collection is conducted using semi-structured interviews, field observations, and documentation of training activities. This process guarantees that the solutions generated are not only creative but also pertinent and useful in real-world scenarios by allowing modules to be constructed in a flexible and contextual way [27]. The learning modules for neurodivergent individuals, including those with cognitive development and sensory conditions, are implemented at LPK ATC Widyatama through a multidisciplinary approach that integrates pedagogical principles, educational technology, and understanding of the needs of the learners' senses. The development of this module is based on the following three contemporary educational philosophies:

- Taksonomi Bloom is revised. This module adopts the Revised Taxonomy of Bloom, which was developed by Anderson and Krathwohl [28]. It emphasizes two primary dimensions: cognitive process (from ideation to creation) and type of knowledge (factual, conceptual, procedural, and metacognitive). This approach is used to support learning objectives that go beyond only imparting knowledge; rather, it also fosters critical thinking, practical skills, and the ability of learners to reflect in real-world situations.
- Sensorial Integration in Adaptive Education: As explained by Schaaf and Mailloux [29], the module is based on the educational philosophy of sensor integration, which holds that sensory interventions can increase neurodivergent individuals' self-regulation and participation. Learning activities are designed to be responsive to the needs of the learners, whether they be visual, auditory, or kinaesthetic, resulting in more flexible, inclusive, and comfortable learning experiences [30].
- TPACK framework in an Inclusive Context: In creative digital learning, the module adopts the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the need to integrate content knowledge, teaching strategies, and digital technology [31]. Through the use of design tools such as Adobe Photoshop and Illustrator, as well as visual aids that are tailored to the individual's characteristics, this training helps students develop their practical skills and become more self-motivated and expressive.
- Social constructivism and context-based learning: According to Vygotsky's social constructivism, which Fosnot *et al* [32] applied in their vocational education, this module advises teaching based on empirical knowledge and social collaboration. Training activities are designed in the form of project-based tasks that are relevant to the workplace, allowing students to develop their understanding through silent practice, teamwork, and discussion of real-world problems, thereby enhancing their work performance and self-confidence in a professional manner.

3. Results and Analysis

3.1. Identification of Initial Needs of Students

The development of the learning module begins with an initial assessment of the students in the Graphic Design class at LPK ATC Widyatama. This assessment includes classifying the type

of disability, talking to the patient about their condition, private advice, digital work, and skills to depict the patient. There are six participants between the ages of 20 and 23 with various types of disabilities, such as autism, deafness, and intellectual disabilities (Table 1). According to the data, the dominant natural stimulation is visual stimulation from video games, movies, or video games, as well as using a laptop as a digital media device. Participant self-limitation includes social, communication, and emotional aspects that are evaluated based on observations of behaviour and statements made by individuals through structured questionnaires. For example, "Social behaviour" refers to the ability to communicate and understand both verbal and nonverbal cues, "Communication" focuses on understanding and communicating verbal and nonverbal cues, and "Emotional" illustrates the importance of understanding and expressing emotions throughout the learning process.

Table 1. Student Data

Name	Sex	Age (years old)	Type of Disability	Natural stimulus	Digital behavior Smart phone/laptop/PC	Self limitation
SN	Boy	20	Autism	Visual	Laptop	Social behavior
DYB	Boy	21	Autism	Visual	Laptop	Social behavior
PRP	Boy	21	Light Autism	Visual	Laptop	Social behaviour, communication
ZAI	Boy	23	Deaf	Visual	Laptop	Communication
FAP	Boy	21	Autism	Visual	Laptop	Emotional
MRAR	Boy	21	Slow learner	Visual	Laptop	Emotional

3.2. Education Without Sensory Accommodation

Training modules lack sensory integration components that are necessary for meeting users' needs. When verbal-only education is provided without visual assistance or theme stimulation, pupils find it difficult to comprehend complex ideas like food design. Natural sensory stimulation adds to emotional instability, which reduces motivation for learning. People with autism have emotional issues that make it difficult for them to participate in class, such as anxiety and bewilderment. Additionally, deaf persons have trouble communicating since the infrastructure does not take into account their demands, which results in inadequate instructions. This encourages people to come up with innovative ideas for designing based on a topic.

3.3. Range of Educational Needs Based on Piaget's Constructivist Theory

According to Piaget's constructivism, the three main domains of student learning needs are as follows: (1) For students to understand design concepts in a comprehensive way, they require realistic and accurate explanations using audiovisual materials and a supportive learning environment; (2) Effectiveness: Improving self-esteem and storytelling skills is crucial for reducing the emotional and social negative effects of disability; (3) Psychomotor: Developing strong and fine motor skills through manual or digital learning materials is essential for advancing the design process.

3.4. Bloom-Based Taxonomy Learning Plan

This study's objectives are based on the Taxonomy of Bloom, which highlights the three main learning pillars of cognitive, affective, and psychomotor. This study integrates the cognitive and social development principles of [33] as well as the inclusive education concept proposed by UNESCO (2020) and the advancements in modern educational technology [34].

- The Cognitive Domain: Through concrete examples and the technique of transferring visual elements from manual to digital media, it is hoped that students will be able to comprehend and internalize the concept of food design. This understanding encompasses not only the aspects of learning and teaching but also effective design analysis and implementation, in line with Vygotsky's theory of cognitive development in the framework of proximal development, which guides learning through social interaction and scaffolding. In this way, students are given the opportunity to learn

actively by utilizing relevant visual stimulation and technological tools, which increases their ability to think critically and creatively in graphic design contexts. This approach also accommodates neurodivergent needs by providing materials that can be tailored through AI-based adaptive education.

- The Affective Domain: The Affective domain encourages students' growth and motivation throughout the learning process. It is expected that the participants would be able to verbally describe their preferred food product, have effective communication skills, and follow instructions with a positive attitude and on time. This is in line with the theories of Vygotsky and Daniels [35], which emphasize the importance of social and environmental interactions in fostering motivation and behavior. According to UNESCO (2020), this kind of affective development is very important in the context of inclusion because it fosters a positive emotional state and self-confidence that can reduce psychological suffering and increase the active participation of people with various needs. The use of sensory-rich media and natural stimulation [36] [37] creates a safe and engaging learning environment, which encourages students to participate.
- The Psychomotor Domain: The psychomotor domain focuses on the ability of the user to develop physical motor skills, which are necessary to produce designs manually or digitally. It is expected that the student would be able to fully understand visual elements, create hand sketches as a first step, and create digital designs using Adobe Illustrator's tools. This development was aided by the Universal Design for Learning (UDL) concept from CAST (2018), which emphasizes the flexibility of teaching methods and technological tools to ensure accessibility for all members of the student body. As per the findings of research on sensory impairment in autism, integrating sensory stimuli into instruction also helps to address the motor needs of neurodivergent students [36]. In addition, the development of digital literacy follows the TPACK (Technological Pedagogical Content Knowledge) principle, which integrates technological, pedagogical, and content knowledge to support effective and contextual learning.

3.5. Development of a Sensorial and Systematic Learning Module

The learning module is designed with the following principles in mind: TPACK, natural sensor integration, and constructivism (Table 2).

Table 2. Variable Module

The purpose of education	The training material	Activities for Learning	Methods of Evaluation and Indicators of Achievement
Cognitive: Understanding the concept of food mascot design	Participant's favorite video, sign language interpreter	Talking about food advertisements, mascots, and shopping simulation	Participants can clearly explain food preparation and follow instructions for mascot design.
Effective: Outlining the mascot function and the designer's approach	Infographics, transcript, PowerPoint, and a sign language interpreter	Interactive discussion on the role of mascot and designer	The active participant responds to discussions and adjusts the design according to the time frame that is specified.
Psychomotor: Manual and digital drawing	For example, an infographic, a manual illustration tool, and a laptop running Adobe Illustrator	Making manual drawings, keeping track of drawings, and displaying digital designs	Participants may provide manual sketches and computer designs in accordance with established standards.

3.6. Module Comparison Before and After Development

Long-term learning modules only focus on cognitive and affective aspects without any kind of stimuli, as well as communication skills that are crucial for understanding. Conversely, the new module integrates cognitive, affective, and psychomotor aspects through the use of natural stimulation, such as video and spoken words, as well as the use of written language and

transcript applications (Table 3). Additionally, education is conducted not only in classrooms but also in real-world settings, allowing for two-way communication, the development of critical thinking skills, and student presentations.

Table 3. Module Comparison

Old Module	Developed Modul
Identification of abilities focused only on cognitive and affective aspects.	Integration of cognitive, affective, and psychomotor aspects
No subjects related to natural stimuli	Learning based on natural stimuli aligned with realistic themes and objects
Sensory development centered on visual aspects	Integration of visual, auditory, and tactile sensory experiences
Relied on communication through lip-reading	Use of transcription apps and sign language
Learning environment centered in classrooms and computer labs (indoor)	Learning outside the classroom and computer lab in accordance with the subject theme
Practical classes did not include the development of two-way learning	Students present concepts, engage in storytelling, and express their feelings

3.7. Implementation Module Based on Natural Stimulation

Natural simulation-based learning allows students to actively participate in the mask-making process. Observation of the product, advertisement video, manual illustration, and design digitization using software are among the activities. This study integrates visual, auditory, and tactile aspects, as well as the environment specifically for deaf users, through the use of transcribing applications and sign language learning. The Participants are also important for expressing design concepts and ideas in presentations.

3.8. Variable Alami Stimulus and Output Design for the Participant

Each person's favorite food is paired with a natural stimulus that represents a known character or theme (Table 4).

Table 4. The Participant

Participant's Name	Favorite Food Product	Natural Stimuli
Satria Nugraha	Chocolate	Japan's character game
Daffa Yusuf Budiman	Popcorn	Marvel movie Aktor
Putu Rangga Putradinata	French Fries	SpongeBob's character
Zidnii Aulia Ilman	Kebab	Love Story movie
Farid Anestiawan Putra	Biscuit	Football theme
Muhammad Ridwan Arsyad	Burger	Robotic theme

3.9. The Visual Asset and Learning Outcomes

The participants used the aforementioned natural stimuli to create the mask through a personification process that begins with a hand sketch and ends with a computer design. For example, Satria transforms SilverQueen's (a chocolate brand), Fig. 1 (a), character from the video game Japan into a mascot chocolate hero, while Daffa creates a superhero mascot based on their favorite Marvel character, Fig. 1 (b). This sensory-based implementation is evaluated using the theories of Bloom, Ayres, Koehler, and Piaget: (1) According to Bloom's Taxonomy [38], student competency in learning does not stop at the stage of remembering and understanding information, but includes higher cognitive levels, starting from the ability to analyze, evaluate, and create [39]. In the understanding stage, students learn to explain concepts and convey information in their own words. Then, they progress to the analysis and evaluation stage, where they distinguish important information, evaluate arguments, and choose the best solution. Finally, the creation stage is when students use their knowledge and skills to create something original. Bloom's Taxonomy helps students develop competencies gradually, from basic to creative thinking, (2) The Sensory Integration Theory, developed by A. Jean Ayres [40], emphasizes that the brain must be able to process and integrate information from multiple senses for a person to respond effectively to the environment. Ayres states that the use of sensory-based learning modules can improve motor skills, discrimination, and sensory modulation through stimulation involving sensory activities. These modules are highly beneficial in supporting physical and cognitive development, particularly for individuals with

sensory processing disorders such as autism, (3) The TPACK approach, developed by Matthew Koehler and Punya Mishra [41], emphasizes the importance of integrating content knowledge, pedagogy, and technology in the learning process. Teachers not only need to master the subject matter and teaching methods, but also must be able to utilize technology appropriately to enhance learning effectiveness. By combining these three elements, TPACK enables the creation of instruction that is adaptive, contextual, and relevant to the needs of learners in the digital age, (4) According to Piaget's theory of cognitive development [42], activities and materials are tailored to the developmental stage of the learner, starting from the pre-operational stage and ending with the specific operational stage. As the learners create the food mascot, this step shows that the inclusion of natural stimulation in the learning module improves their motivation, two-way communication skills, and cognitive capacities.

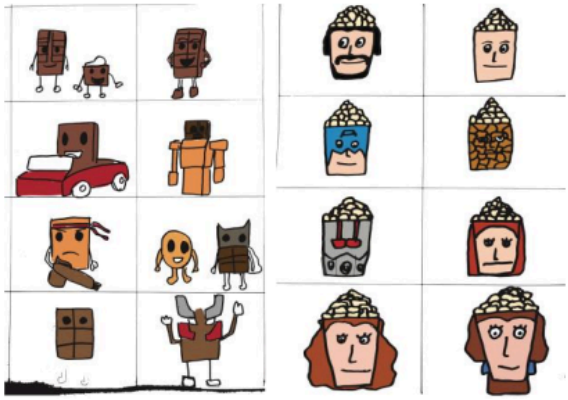


Fig. 1. (a) Satria – Chocolate; (b) Daffa – popcorn

Silverqueen chocolate bars were the first food Satria identified as his favorite because he adores chocolate. The Japanese video game characters he plays are another natural trigger in the context of audiovisual sensory experiences. The chocolate changes into a hero figure with multiple roles and expressions, resembling a game character. Daffa, in the meantime, enjoys popcorn, and characters from other Marvel films provide another source of stimulation for him. Putu has been heavily impacted by the SpongeBob film, Fig. 2 (a), and Fig. 2 (b). This movie is a typical component of everyday activities as a natural audiovisual stimulation. French fries were selected because they are thought to be the most identifiable food. Daffa, on the other hand, is naturally stimulated by romantic drama films and likes kebabs. His everyday life and hobbies are greatly influenced by these movies, which deal with love and relationships.

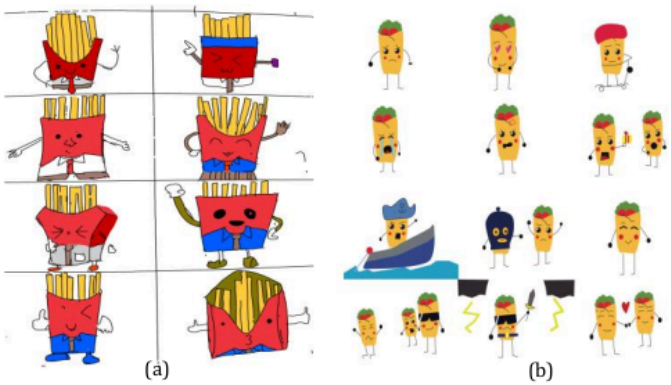


Fig. 2. (a) Putu – French fires; (b) Zidni-meanwhile Kebab

Football and biscuits are Farid's natural stimulants, and he prefers them, Fig. 3 (a). The dynamic and fun aspect of football serves as an inspiration for his artistic work, which frequently uses the shape and color of biscuits to capture different feelings of excitement.

Ridwan, meanwhile, is fascinated by robot themes and likes burgers, Fig. 3 (b). This impact is clear in his work, as his fascination with robotic characteristics is seen in the frequent depictions of mascot characters as stiff and mechanical.

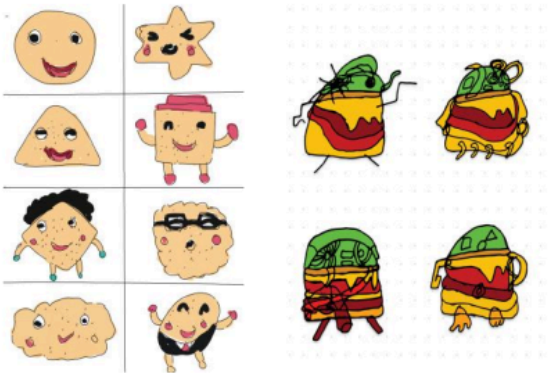


Fig. 3. (a) Farid - Biscuit; (b) Ridwan - Burger

4. Conclusion

In the Graphic Design Program at LPK ATC Widyatama, this study created and executed a sensory-based vocational training module for neurodivergent people, especially those with mental, intellectual, and hearing difficulties. To improve participants' comprehension, engagement, and practical abilities, the module was created with a multimodal approach and natural stimuli (such as their favorite characters from video games and movies). The results show that individualized sensory integration enhances motivation, facilitates more efficient two-way communication, and enhances cognitive, emotional, and psychomotor learning outcomes. In order to produce meaningful and imaginative mascot-based food designs, participants were able to effectively relate their favorite visual experiences to design problems. Nevertheless, the study also discovered that implementation necessitates paying close attention to the variety of student demands and class size. There was only one instructor, which made it difficult to manage paperwork and offer tailored assistance. Furthermore, because the participants' intellectual capacities varied, it was impossible to quantify cognitive consequences. This study emphasizes the value of adjusting training to each learner's particular traits and preferences while offering a fundamental model for inclusive vocational education based on sensory learning techniques.

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Declarations

Author contribution	:	All authors contributed equally to the conceptualization, design, implementation, and analysis of the study. AN led the module development and field testing; FH assisted with data collection, documentation, and manuscript preparation.
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Conflict of interest	:	The authors declare no conflict of interest.
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