Technology Enhanced Mulsemedia Learning (TEML) for Learners with Dyslexia

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Mulsemedia-multiple sensorial media- includes both traditional multimedia and human sensorial effects, which gives immersive real-world experience. The booming of new technology and wearable devices creates a new avenue for Mulsemedia research in education and has brought new opportunities for Technology Enhanced Mulsemedia Learning (TEML). Traditional methods focus on unisensory experiences, even though the surrounding environment is multisensory. Moreover, this type of learning helps to stimulate various sensory channels to reinforce the learning process, which can also more benefit individuals with a variety of learning disabilities particularly dyslexia which affects a person's ability to read. Moreover, TEML helps to obtain 21st-century learning skills such as cognitive, productivity, social-cultural, metacognitive, and technological dimensions. This paper proposes TEML for learners with dyslexia, for that, this study focuses on an approach for identifying methods for dyslexia, a method for designing Mulsemedia devices using IoT technology, and an evaluation method for performing quality of experience (QoS) using questionnaire, and physiological signals such as GSR (Galvanic Skin Responses), and EEG (Electroencephalography). Those methods help to analyze the learner's emotional responses while experiencing Mulsemedia content.

CCS Concepts: • **Human-centered computing** → **Interaction paradigms**; • **Information systems** → **Multimedia information systems**.

Additional Key Words and Phrases: Mulsemedia, Technology Enhanced Mulsemedia Learning, Quality of Experiences, Dyslexia, Learning Disability

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1 INTRODUCTION

In recent years, educators are taking many initiatives for improving students' motivation, engagement, and academic performance, especially in STEM (Science, Engineering, Technology, Mathematics) subjects. However, normal students can easily adapt concepts, but it is not easy for slow learners (dyslexia). Out of many learning

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disabilities, Dyslexia is a specific learning disability that affects the reading accuracy and fluency of learners in learning [13, 17]. The latest advancement in technology has enabled a wide range of opportunities for e-learning methods by providing learners with diverse technology devices, and solutions for enhancing the learning experiences, especially for learners with disabilities. Furthermore, NEWTELP [20] projects show the impact of Technology Enhanced Learning (TEL), and how enables mulsemedia enhanced teaching and learning in STEM subjects for normal students, which is mainly focused on Telecommunication and Networking related modules [20, 21].

Mulsemedia is a term that combines multimedia content (Audio, Video, Image, text, etc.,) and human sensory channels [7]. Mulsemedia content includes audio-visual components, and metadata to trigger stimuli for other senses (touch, smell, taste). STEM education gives special attention to practical training that facilitates a deep understanding of design procedures, practical limitations, and engineering trade-offs. Due to technological development, different kinds of technology are involved in engineering education such as multisensory virtual and augmented reality and game-based learning [3, 4]. Designing mulsemedia content includes the real-time environment experience when reading e-content. In addition, while developing a typical Mulsemedia delivery system, one needs to consider the following workflow. (1) Creation of Mulsemedia content, (2) content distribution and reception, (3) synchronize the content to the end-user via a collection of devices with different senses (e.g., haptic, taste, olfactory, airflow, and waterjet). Mulsemedia learning theories help to stimulate the various sensory media for reinforcing the learning process [5]. Elsharif et al. [6] have reported that the help of Mulsemedia creates a major impact to solve problems in rehabilitation technologies, assistive technology, and learning disability. Moreover, the previous finding shows that when providing sensory cues while reading, his/her cognitive load is reduced and learning enhanced [2]. However, learning environments based on mulsemedia can provide an immersive and interactive learning experience that can significantly increase motivation and engagement [2]. Furthermore, mulsemedia-based learning environments can provide immediate feedback, allowing learners with learning disabilities to track their progress and identify areas for improvement. This is especially useful for students with disabilities who may struggle with self-monitoring and self-regulation [18].

The level of satisfaction and engagement that learners experience during the learning process is referred to as QoE in the context of learning [10, 17]. It takes into account a variety of factors, such as the effectiveness of the teaching methodology, the quality of the learning materials, the relevance of the content to the learner's needs, and the level of interactivity and feedback provided during the learning process. The use of mulsemedia in STEM education can significantly improve QoE in learning by providing learners with an immersive and engaging learning experience that accommodates various learning styles. One of the primary advantages of using mulsemedia in education is the ability to create highly interactive and personalized learning experiences. The quality of experience in learning is critical for ensuring that learners achieve their learning objectives in an effective and efficient manner. It is a measure of the effectiveness of the learning experience and can influence learners' motivation, engagement, and knowledge retention. Recent studies [11] show that mulsemedia can improve the quality of experience of learners while affective computing can capture the individual affective states during reading (e.g., sleep and boredom). In addition, this study evaluates the possible changes of detection when reading. For evaluating the quality of experience of learner questionnaires and biosignal responses are commonly used to analyze the state of learner engagement in Mulsemedia learning. Furthermore, technology enhanced mulsemedia learning gives a potential benefit to create an active learning environment and helps to develop motivation and self-esteem by allow learners to take responsibility for their learning.

This paper has been divided into the following sections: Section 2 explains the proposed approach for technology-enhanced Mulsemedia learning for learners with dyslexia. Section 3 describes the evaluation approach for quality of experience (QoE). Finally, Section 4 concludes the overall approach of Mulsemedia learning for learners with dyslexia.

2 TECHNOLOGY ENHANCED MULSEMEDIA LEARNING (TEML) WEB PORTAL

Technology Enhanced Mulsemedia Learning (TEML) web portal aims to provide a comprehensive e-learning platform for individuals with dyslexia. This portal focuses on developing an inclusive and accessible platform that caters to the needs of individuals with dyslexia, providing them with specialized tools and resources to enhance their quality of experience and analyses emotional state of learners while learning.

The TEML web portal not only provides an accessible and inclusive learning experience but also incorporates STEM concepts to promote scientific literacy and critical thinking skills. The educational learning resources related to Biology and Physics include interactive simulations like airflow, olfaction, video, audio and vibration, and the multimedia web portal content is designed to help individuals with dyslexia grasp concepts regarding STEM area [16].

2.1 Mulsemedia based Web portal

The methodology used in the development of the TEML web portal includes five phases which includes gathering learning materials, device preparation, prototype for experimentation, analyzing the quality of experience (QoE), and emotion analyses.

Technology plays a critical role in addressing the challenges faced by individuals with dyslexia, and the TEML platform is designed with specialized devices and tools. The important unique feature of the TEML web portal is the synchronization of the specialized device with Arduino code to trigger the exhaust fan, humidifier, and vibration to create a multisensory learning experience [9]. In addition, the web portal incorporates olfactory stimuli into the learning experience. By triggering the Arduino code with XML in the web portal, the platform emits the smell of rosemary which has been used to enhance cognitive function and memory retention while learning [1]. The Arduino code is programmed to work in sync with the audio content, ensuring that the fan works on time. This synchronization of devices and video content creates an immersive learning environment that engages learners and promotes active learning. These devices are designed to reduce the impact of environmental factors on learning and enhance the learning experience for individuals with dyslexia. To identify individuals with dyslexia is a challenging task, as IQ and language are not needed to identify the disorder. Dyslexia is a specific learning disability in reading words, spelling of words and working memory capacity are necessary for identifying dyslexia. The dyslexia question preparation module helps individuals with dyslexia improve their reading and comprehension skills. This module includes a range of exercises and activities designed to improve phonological awareness, decoding, fluency, vocabulary, and comprehension. The dyslexia question preparation module is personalized to meet the specific needs of each individual and provides immediate feedback to help learners track their progress. This questionnaire includes assessing reading performance, identifying individual letters, and spelling of more relevant words. This innovative approach to dyslexia intervention is a testament to the TEML web portal's commitment to creating an inclusive and accessible platform that meets the diverse learning needs of individuals with dyslexia. Thus, the study represents a significant advancement in the field of dyslexia intervention and education. It has the potential to revolutionize the way individuals with dyslexia learn and provide them with equal access to STEM education and other learning opportunities [12]. With further development and refinement, the TEML web portal could serve as a model for other platforms seeking to create a more inclusive and accessible learning environment for individuals with diverse learning needs.

3 EVALUATION APPROACH

The evaluation approach for the Technology Enhanced mulsemedia learning (TEML) web portal includes QoE questionnaire, EEG, and GSR sensors to collect the data and analyses experience of learners. Those are an evolutionary approach for multisensorial learning, which provides valuable insights into user engagement and emotional impact. These methods are to be chosen to provide both objective and subjective measures of cognitive

and emotional responses [22]. The EEG and GSR measurements provide objective measures of cognitive and emotional responses to the learning content on the platform. This data can be used to optimize the learning experience and modify the content to meet the specific needs of each individual with dyslexia.

The subjective measures are important in QoE evaluation because they provide direct feedback from participants, which can help to identify the strengths and weaknesses of a mulsemedia application. This assessment provides a subjective measure of how the participants perceived the proposed Technology-enhanced Mulsemedia learning (TEML) web portal. The assessment included questions about learning content, questions about specific elements such as olfactory, airflow, vibration and QoE questions to evaluate the mulsemedia experience. Here, Open-ended questions allow participants to provide detailed and personalized responses, while Likert scale questions can provide quantitative data that can be analyzed statistically [4, 19]. Participants fill out the questionnaire after watching the learning with mulsemedia effects. Moreover, this type of analysis is not more efficient to analyze the learners real QoE because when learners explore new fields of experience.

These subjective measures of quality of experience are important to consider alongside the objective measures of cognitive and emotional response recorded in the Technology-enhanced Mulsemedia learning (TEML) Web portal [4]. It provides a holistic understanding of the listener's experience with the TEML web portal and suggests that multisensorial elements can contribute to a positive listening experience. Overall, the evaluation approach employed in this research provides a comprehensive understanding of the cognitive and emotional responses to the TEML web portal. The EEG and GSR data provide objective measures of these responses, while the quality of experience assessment provided a subjective measure [8, 14].

An EEG device is a tool that measures the electrical activity of the brain using electrodes attached to the scalp. The EEG device can be used to measure the brain activity of participants in response to specific stimuli, providing insights into cognitive processes and emotional responses [14, 15]. The EEG data is collected using a 16-channel wireless EEG headset. Participants were instructed to wear the headset while listening to the audio, and data is collected for the entire listening session. The data is analyzed using open-source software, focusing on three types of brain waves: alpha, beta, and theta waves. Alpha waves are associated with relaxation and calmness, beta waves with cognitive load and attention, and theta waves with relaxation and mental imagery.

GSR (Galvanic Skin Response) is a measure of the electrical conductance of the skin, which can be used to monitor changes in the activity of the sympathetic nervous system. GSR is also known as Skin Conductance (SC) or Electrodermal Activity (EDA) [11]. GSR data is collected using a wristband sensor that measures changes in skin conductance. This method provides an indication of physiological arousal and is used to identify the emotional impact of the Mulsemedia on participants. First, the participants were instructed to relax for two minutes. The index and middle fingers on the left hand were then fitted with the GSR finger sensor [11]. The GSR data was analyzed by examining the changes in skin conductance over time, particularly in response to key moments of the multisensorial effects in that audio. The GSR analysis showed that participants experienced significant increases in physiological arousal during intense and emotional scenes. These findings suggest that the multisensorial elements of the web portal are successful in eliciting emotional responses from participants.

Furthermore, the objective method gives a more accurate state of learners, and also helps to detect hidden information. However, some limitations are in objective measure such as cost of device, controlled environment, and learners not comfortable with wearable devices.

4 CONCLUSION

In conclusion, the Technology Enhanced Mulsemedia Learning (TEML) web portal represents a major step forward in the field of education and learning. It provides an inclusive and engaging platform for learners of all abilities, including those with dyslexia. With the incorporation of STEM concepts, Mulsemedia learning has the potential to provide even greater benefits. By incorporating a variety of leveraging technology such as

the Arduino microcontroller, exhaust fans, humidifiers-olfactory sensors, and even haptic feedback devices to create a truly multisensory learning experience. This creates a rich and engaging learning experience that is accessible to a wide range of learners, including those with dyslexia. Moreover, TEML incorporates a quality of experience evaluation approach that utilizes EEG and GSR sensors to collect data on cognitive and emotional responses. Overall, the TEML web portal initiative represents a major step forward in the field of education anad learning, offering a truly immersive and effective learning experience that leverages the latest technologies and best practices.

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