

DEVELOPMENT OF ARTIFICIAL INTELLIGENCE-BASED ADAPTIVE LEARNING MEDIA TO SUPPORT INCLUSIVE EDUCATION FOR PUPILS WITH DIVERSE LEARNING NEEDS

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Abstract

Inclusive education requires the availability of learning resources capable of accommodating the diversity of pupils' abilities, characteristics, learning styles and individual needs. Conventional learning resources, which tend to be uniform, have not yet been fully able to provide a flexible and personalised learning experience, particularly for pupils with diverse learning needs. This article aims to analyse the concept, design and implementation of Artificial Intelligence (AI)-based adaptive learning resources in support of inclusive education. This study employs a literature review using a descriptive-qualitative approach, analysing various scientific articles, academic books, reports from educational institutions, and relevant policy documents. The findings indicate that AI can help tailor content, difficulty levels, learning pace, presentation formats, activities, assessments, and feedback based on students' profiles and progress. Adaptive learning media can also support accessibility through text-to-speech, speech-to-text, transcripts, visualisations, language simplification, and personalised learning recommendations. However, its implementation still faces challenges in the form of infrastructure limitations, teachers' competence readiness, the digital divide, algorithmic bias, data security, and the need for human supervision. Therefore, the development of AI-based adaptive learning tools must be grounded in the principles of inclusive education, Universal Design for Learning, data protection, equity, transparency, and collaboration between teachers, pupils, parents, technology developers, and policymakers. When implemented responsibly, AI can serve as a strategic tool for creating learning experiences that are more personalised, flexible, accessible, and responsive to pupils' diverse learning needs.

Keywords: adaptive learning materials, *Artificial Intelligence*, inclusive education, diverse learning needs, personalised learning, educational accessibility.

Introduction

Inclusive education is an educational approach that recognises the diversity of learners as a vital part of the learning process. In inclusive education, every pupil—including those with disabilities, learning difficulties, varying academic abilities, socio-cultural backgrounds, languages, or other personal characteristics—has the right to equal and meaningful learning opportunities. Inclusive education is not merely about placing pupils with special needs in mainstream classes, but also requires adjustments to the curriculum, teaching methods, the learning environment, assessment, and

learning materials so that all pupils can participate and achieve learning objectives to the fullest extent possible (Supriyanto et al., 2026). Consequently, the success of inclusive education is largely determined by the education system's ability to identify and reduce various barriers that may limit pupils' participation in the learning process. Sudarto, (2016) emphasises that inclusion encompasses efforts to accommodate the needs of every learner and ensure that all pupils can learn and develop together.

The diversity of pupils' learning needs is a reality that cannot be ignored in the delivery of modern education. Within a single class, a teacher may encounter pupils with high academic ability, those requiring repetition of material, those with reading or numeracy difficulties, those with sensory and motor impairments, and those experiencing difficulties with concentration, communication or emotional regulation. These differences demonstrate that pupils do not all have the same approach, pace, or level of readiness for learning. If all pupils are provided with the same material, activities, duration, and form of assessment, some pupils may struggle to understand the material and demonstrate their competence. Therefore, learning must be designed flexibly, taking into account students' individual profiles, needs, interests and development (Lindner et al., 2021). An approach that is responsive to this diversity forms a crucial foundation for the development of learning resources capable of tailoring the learning experience to a more personalised level.

One of the main challenges in implementing inclusive education is the limitation teachers face in providing individual support to all pupils simultaneously. Teachers are not only responsible for delivering content, but also need to carry out diagnostic assessments, monitor pupils' progress, provide feedback, prepare alternative materials, and design interventions for pupils experiencing learning difficulties. In classes with large numbers of pupils and a high degree of heterogeneity, delivering truly individualised learning is often difficult to maintain consistently. This situation can result in pupils with specific learning needs receiving inadequate support. Therefore, technological support is required to help teachers manage learning data, identify patterns of pupils' difficulties, and provide suitable alternative materials or activities without undermining the teacher's role as the pedagogical decision-maker (Rifky, 2024); (Aslan Aslan & Pong, 2026).

Advances in digital technology and artificial intelligence (AI) present new opportunities for developing more adaptive learning resources. AI enables systems to process various types of learning data, such as assessment results, response patterns, task completion times, error rates, student interaction with the material, and activity completion rates. This data can be used to predict students' learning needs and provide more appropriate learning recommendations. In an educational context, AI can support personalisation through intelligent tutoring systems, content recommendations, automated feedback, learning analytics, natural language processing, and speech and text recognition technologies (Shatila, 2025). The use of AI is therefore not only geared towards the automation of learning but also towards

creating learning experiences that are more responsive to students' individual characteristics.

Adaptive learning media is one form of innovation that can be developed through the use of AI. This media is designed to tailor the material, level of difficulty, sequence of learning, form of presentation, type of exercises, and feedback based on students' learning profiles and responses. Unlike conventional learning media, which tends to provide the same content to all students, adaptive media allows each student to follow a different learning path according to their needs and abilities. An adaptive learning system can essentially be understood as a computer system that adjusts content, presentation style, or learning pathways based on students' individual learning profiles and progress (Widjaja & Aslan, 2022). Such adaptation can help students face appropriate challenges, reduce cognitive load, and provide opportunities to learn through more accessible methods.

The development of adaptive learning media is also closely linked to the principles of Universal Design for Learning (UDL). UDL emphasises the importance of providing a variety of ways to engage students, present information, and enable students to express their knowledge and competences (Kalantzis & Cope, 2004). These principles are relevant to inclusive education because learning barriers do not always stem from students' limitations, but can also arise from inflexible designs of the learning environment and learning materials. Through AI support, the UDL principles can be applied by providing materials in the form of text, audio, video, visualisations, transcripts, screen readers, translation, and alternative response formats. Thus, learning media not only adjust the level of difficulty of the material but also provide various ways for pupils to access, understand and demonstrate their learning outcomes.

In practice, AI-based adaptive learning resources can provide support for students with diverse learning needs. Students with reading difficulties can access text-to-speech features, simplified sentences, or vocabulary support (Wibawa, 2021). Students with hearing impairments can access transcripts, text, and visualisations of information. Pupils who struggle to understand abstract concepts can benefit from simulations, illustrations, concrete examples or step-by-step explanations. Meanwhile, pupils who have mastered certain competences can be provided with enrichment materials and additional challenges. Such adaptations enable learning to move away from a 'one-size-fits-all' approach towards learning that takes into account the needs and responses of each pupil (Satrio, 2022). However, the implementation of these features must be based on accurate assessment and must not rely solely on AI data to determine pupils' abilities or potential.

As well as supporting personalisation, AI-based adaptive learning resources have the potential to enhance pupils' engagement and independence. When material is presented in line with pupils' ability levels, interests and preferences, the learning process can become more relevant and less overwhelming. Prompt feedback can also

help pupils understand their mistakes and refine their learning strategies. Smart tutoring systems, for example, can provide step-by-step guidance before students arrive at the final answer, thereby keeping them engaged in the thought process. Research on intelligent tutoring systems indicates that this technology can provide structured learning support and individualised feedback, although its effectiveness remains dependent on the quality of the pedagogical design and its integration with teacher-led learning (Kulik & Fletcher, 2016). Therefore, AI should be used to enhance learning activities, rather than merely to speed up the delivery of answers.

Whilst offering a range of opportunities, the use of AI in inclusive education also presents ethical and pedagogical issues that require attention. AI systems operate on the basis of data, algorithms and predictive models that may contain bias if the data used does not represent the diversity of pupils. Classification errors can result in pupils being provided with material that is too easy, too difficult or unsuitable for their needs. Furthermore, the collection of data regarding pupils' abilities, behaviour, health conditions or special needs poses risks to privacy and data security. Toader et al., (2023) emphasise that the use of AI in education must be grounded in a human-centred approach, protect personal data, promote inclusion and equality, and prevent discrimination stemming from data or algorithms. Consequently, the development of adaptive learning materials must incorporate the principles of transparency, accountability, data protection and human oversight from the design stage onwards.

Another challenge relates to the digital divide concerning access to devices, internet connectivity, digital resources and technological competence. Adaptive learning materials will not provide equal benefits if they can only be used by pupils who have adequate devices and a stable internet connection. The digital divide can exacerbate inequality if AI technology is implemented without taking into account pupils' socio-economic, geographical, linguistic and cultural circumstances. Furthermore, teachers require training to be able to use the tools, interpret system recommendations, verify the accuracy of AI outputs, and link digital data with pedagogical observations. Rahman & Aslan, (2025) emphasise the importance of a hybrid approach that combines human capabilities and AI to support personalised learning. In this approach, AI functions as an analytical tool and recommendation provider, whilst teachers retain the primary role in understanding the context of their pupils and determining appropriate learning interventions.

The development of AI-based adaptive learning materials must also be linked to the rights of students with disabilities to receive an inclusive, high-quality and equitable education. The United Nations Convention on the Rights of Persons with Disabilities stipulates that states must guarantee an inclusive education system at all levels, provide appropriate accommodation, and offer the necessary individual support within mainstream educational settings (Asmini, 2025). These principles indicate that educational technology should not be developed solely to improve efficiency, but must also be used to remove barriers and provide appropriate support for pupils. Adaptive

learning tools need to be co-designed by teachers, pupils, parents, special education experts and technology developers to ensure that the resulting features are truly relevant to users' needs. The involvement of pupils with special needs is crucial so that the development process is not based on one-sided assumptions regarding their abilities or limitations.

Based on the above, the development of AI-based adaptive learning resources is a key issue in efforts to strengthen inclusive education. This technology has the potential to provide learning that is more personalised, flexible, accessible and responsive to the diversity of pupils. However, this potential can only be realised if the development of such resources is grounded in sound pedagogical principles, accessibility design, appropriate needs assessment, teacher involvement, equitable infrastructure, and the protection of students' rights and data. Therefore, this article discusses the development of AI-based adaptive learning resources through two main focuses: the concepts and design of AI-based adaptive learning resources, and implementation strategies to support inclusive education for students with diverse learning needs. It is hoped that this discussion will provide a conceptual and practical foundation for teachers, educational media developers, researchers, and policy-makers in designing the use of AI that is innovative, ethical, and oriented towards learning equity.

Research Methodology

This study employs a literature review using a descriptive-qualitative approach to analyse various relevant academic sources concerning the development of AI-based adaptive learning materials in support of inclusive education. Research data were obtained through a search of national and international journal articles, academic books, reports from educational institutions, policy documents, and scientific publications discussing artificial intelligence, adaptive learning, inclusive education, Universal Design for Learning, personalised learning, and diverse learning needs (Walliman & Walliman, 2021). Literature sources were selected based on thematic relevance, publisher credibility, recency of publication, and their contribution to the research focus. Data analysis was conducted through the stages of identification, selection, grouping, interpretation, and synthesis of information to identify concepts, benefits, forms of application, challenges, and principles for the development of AI-based adaptive learning media. The results of the analysis are presented narratively, integrating key findings from various sources to gain a comprehensive understanding of the potential and strategies for utilising AI in creating learning that is inclusive, personalised, flexible, and tailored to the diverse learning needs of pupils (Elijah & Aslan, 2025).

Results and Discussion

Concept and Design of AI-Based Adaptive Learning Media

Artificial Intelligence (AI)-based adaptive learning media is a digital medium designed to tailor the learning experience according to the characteristics, needs, abilities, responses and development of each learner. Such adaptation may include the selection of material, level of difficulty, order of presentation, format of activities, duration of learning, and the type of feedback provided. Unlike conventional learning media, which generally present the same content to all pupils, adaptive media allow each learner to follow a different learning path in line with their individual learning circumstances. Adaptive learning places the student at the centre of the learning process, as the system seeks to respond to individual needs rather than forcing all students to follow a uniform learning pattern (Arnadi et al., 2024); (Nasution & Aslan, 2025). Thus, AI-based adaptive media can be understood as a combination of digital technology, learning data analysis, and pedagogical principles oriented towards personalisation.

The key concept in adaptive learning media is the system's ability to make dynamic adjustments. These adjustments are not only made at the start of the learning process based on the results of diagnostic tests, but also continue throughout the learning process through the analysis of students' interactions with the media. The system can identify correct and incorrect answers, task completion times, error patterns, the frequency of material repetition, and students' responses to various types of activities. This information is then used to determine the next material, provide additional practice, or increase the level of difficulty. Within this framework, learning does not proceed linearly, but forms a learning pathway that can change in accordance with the student's progress. This type of adaptive model enables the media to respond more quickly to learning needs compared to media that rely solely on a fixed learning design (X.-Y. Wu, 2024).

Artificial Intelligence acts as a component that enables learning media to perform computational analysis, prediction, recommendation and decision-making. Technologies such as machine learning can be used to recognise students' learning patterns, whilst natural language processing can support interaction via chatbots, analysis of open-ended answers, or language simplification. Speech recognition technology can assist students who face difficulties with typing, whilst text-to-speech and speech-to-text features can enhance the accessibility of learning materials. AI can also be used to generate questions, provide guidance, identify misconceptions, and recommend learning resources. Nevertheless, AI should not be positioned as a substitute for teachers, but rather as a supporting technology that helps teachers gain more comprehensive information about students' learning processes (Safrudin, 2026); (Astuti et al., 2023). Studies on adaptive system design also indicate that AI can be used to analyse learning data in real time and adjust learning pathways as well as the level of difficulty of the material.

The design of AI-based adaptive learning media must begin with an understanding of learners' needs and characteristics. Needs analysis encompasses the identification of prior knowledge, learning objectives, learning barriers, access preferences, learning environment conditions, and the support available to pupils. In the context of inclusive education, needs analysis must not focus solely on pupils' deficiencies or limitations, but must also identify their strengths, interests, learning strategies, and potential for development. This data is then used to design flexible and non-discriminatory learning experiences. Data collection can be carried out through diagnostic assessments, teacher observations, interviews, questionnaires, analysis of learning outcomes, and students' interactions with learning materials. However, the types of data collected must be strictly relevant to the learning objectives and protected by adequate security and privacy procedures (Saban & Normuliati, 2026); (Sa'adah et al., 2026).

One key component in the design of adaptive media is the learner profile. The learner profile contains information describing a student's abilities, needs, progress, interests, access preferences, and patterns of interaction with the learning material. This profile should not be understood as a permanent label that defines a student's abilities, but rather as dynamic information that can change in line with the learning process. For example, a student who initially struggles to understand a mathematical concept may show improvement after being provided with visualisations and gradual practice. Therefore, the system needs to update the profile periodically based on the latest evidence of learning. A well-designed profile can help AI provide more relevant recommendations, whilst teachers can use it to plan more targeted learning interventions and support (Rahman & Aslan, 2025).

The next component is the domain model, which contains the structure of knowledge, competences, content, learning indicators and relationships between concepts. The domain model serves as a knowledge base used by the system to determine the content that pupils need to learn. Each topic must be linked to specific competences, a level of difficulty, prerequisite knowledge, and appropriate activity types. If a student has not yet mastered the prerequisite competences, the system can direct them to remedial material before proceeding to the next topic (Band et al., 2018). Conversely, students who have mastered certain competences can be provided with enrichment material or more challenging tasks. Thus, adaptive learning media not only adjust the number of exercises but also construct learning pathways based on the logical interconnections between knowledge and competencies.

In addition to the domain model, adaptive learning media require a pedagogical model that governs how learning is delivered to pupils. The pedagogical model determines the strategy for presenting material, the type of assistance, the sequence of activities, the form of exercises, the method of providing feedback, and the criteria for progression to the next level of learning. In practice, the system may utilise a step-by-step learning approach, targeted repetition, problem-based learning, simulations,

educational games, or intelligent tutors. The pedagogical model must remain aligned with the learning objectives and the characteristics of the subject. AI can provide recommendations based on data patterns, but pedagogical decisions need to be validated by teachers because quantitative data cannot always fully capture students' social, emotional and contextual circumstances (Williamson, 2024). Therefore, the design of the learning platform must provide scope for teachers to modify, reject or adapt the system's recommendations.

The adaptation engine is the core component that links student data, learning content and learning decisions. This engine analyses data obtained from student activities to determine the system's response. If a student makes repeated errors, the system can present alternative explanations, simpler examples or prerequisite exercises. If a student is able to complete a task quickly and accurately, the system can increase the level of difficulty or provide enrichment activities. Adaptation can be based on specific rules, recommendation algorithms, predictive models, or a combination of several methods. In designs for inclusive education, the adaptation engine must be tested to ensure it does not produce decisions that are biased against pupils with disabilities, language differences, or non-standard learning styles. The system must also allow teachers to understand the reasoning behind the recommendations provided so that AI decisions can be held accountable (Nusantara & Pramono, 2026).

Content design is another crucial aspect, as AI can only produce high-quality adaptations if structured and diverse learning content is available. Content needs to be developed across various levels of difficulty, presentation formats, material length, and types of activities. A single concept can be presented through text, images, audio, video, animations, simulations, case studies, or interactive exercises. Materials also need to be accompanied by metadata, such as the targeted competences, difficulty level, prerequisites, estimated time, keywords, and forms of accessibility support (Bawamenewi & Waruwu, 2023). A well-organised content structure makes it easier for the system to select materials that suit students' needs. In the context of inclusive education, the provision of various formats is not intended to rigidly categorise pupils, but to offer choice and flexibility so that pupils can access information in the way that best supports their learning process.

The principles of Universal Design for Learning (UDL) can serve as a foundation for designing adaptive media content and interfaces. UDL emphasises providing a variety of ways to engage students, represent information, and express their knowledge and competences (Kalantzis & Cope, 2004). These principles can be applied through the choice of font size and type, colour contrast, alternative text for images, video transcripts, audio descriptions, keyboard navigation, screen readers, and response options. The media should also allow learners to set their own learning pace, repeat explanations, choose the format of the material, and use support as required. Accessible design should not be added after the media has been created, but

incorporated from the analysis and design stages onwards. In this way, accessibility becomes a key characteristic of the media, rather than an additional feature used only by certain groups of students.

The user interface should be designed to be simple, consistent, intuitive and free from unnecessary cognitive load. Students must be able to understand the function of each button, know where they are in the learning path, and receive clear information about the tasks they need to complete. The use of colour, animation, sound and notifications must be controlled so as not to disrupt concentration or cause excessive stimulation for certain learners (Becan & Çeber, 2025). The platform should also provide personalisation options, such as adjusting text size, enabling sound, selecting a language, disabling animations, or changing the display layout. Furthermore, the system must provide error messages and instructions that are easy to understand. A good interface not only focuses on aesthetic aspects but also takes into account the user's motor, sensory, cognitive and language abilities (Bond et al., 2018). Therefore, interface testing needs to involve students with diverse characteristics.

Feedback is the feature that distinguishes adaptive media from standard digital media. Good feedback does not merely state whether a pupil's answer is correct or incorrect, but also explains the reasoning, highlights areas for improvement, and provides guidance on how to complete the task. Feedback can be provided directly through the system or followed up by the teacher based on information on the learning dashboard. For students experiencing difficulties, the system can provide step-by-step assistance to encourage them to continue attempting to complete the task independently. Feedback must also take emotional aspects into account by using supportive and non-judgemental language. Where AI generates automated feedback, the quality and accuracy of the information must be verified regularly to ensure students do not receive incorrect or confusing explanations (Waelen, 2023).

AI-based adaptive learning platforms also need to be equipped with a teacher dashboard that serves as a tool for monitoring and decision-making. The dashboard can display pupils' progress, competencies they have mastered, material they have not yet understood, error patterns, frequency of help usage, and recommendations for follow-up actions. This information must be presented in a simple and meaningful way so that teachers not only receive data but can also use it to plan their teaching. The dashboard should not display too many indicators that are difficult to interpret (Buckingham, 2015). Teachers need to be informed of the reasons why the system makes certain recommendations, as well as the confidence level of the AI's predictions. In this way, teachers can combine information from the system with direct observation, communication with pupils, and professional judgement. Such integration is important because pupils' learning progress cannot always be fully represented through digital data (Dwi Puja Syaharani, 2024).

Security, privacy, transparency and fairness must be integral aspects of the design of adaptive learning media. Pupil data, particularly data concerning disabilities,

learning difficulties, health conditions and learning behaviour, constitutes sensitive information that must be managed responsibly. The system must implement access restrictions, secure storage, the use of data for its intended purposes, and clear consent mechanisms. Students, parents and teachers must be provided with information regarding the data collected, the purposes for which it is used, and the parties who may access it. Furthermore, algorithms must be tested to identify potential biases that could disadvantage certain groups of pupils. Arnadi et al., (2024) emphasise the importance of a human-centred approach to the use of AI, including privacy protection, capacity building for teachers, and the prevention of inequality. Consequently, the design of the media must consider social and ethical impacts, not merely its technological functions.

Overall, the concept and design of AI-based adaptive learning media need to integrate three key dimensions: the pedagogical, technological and inclusivity dimensions. The pedagogical dimension ensures that the media supports learning objectives, teaching strategies, assessment and the development of pupils' competences. The technological dimension ensures that the system is capable of processing data, providing recommendations, facilitating interaction and operating securely. Meanwhile, the inclusivity dimension ensures that the media can be accessed, used and provides benefits for students with diverse learning needs. The development of such media should be carried out iteratively through needs analysis, prototype design, expert validation, accessibility testing, limited trials, user evaluation and continuous refinement. Such an approach is in line with the development of adaptive media, which prioritises needs analysis, validation, pilot testing, and evaluation as crucial stages in producing viable and beneficial products. With a systematic and human-centred design, AI can serve as a tool to strengthen inclusive education, rather than creating new forms of exclusion.

Implementation of Adaptive Learning Media to Support Inclusive Education

The implementation of Artificial Intelligence (AI)-based adaptive learning media in inclusive education is a process of applying technology aimed at tailoring the learning experience to the characteristics and needs of each pupil. Such media can help provide different materials, activities, feedback and assessments based on pupils' prior knowledge, learning pace, barriers and progress. In inclusive education, the implementation of adaptive media is not only aimed at improving learning outcomes but also at ensuring that pupils with diverse learning needs can actively participate in the learning process. Therefore, the application of technology must be situated within a pedagogical framework oriented towards equity, accessibility, and respect for pupil diversity (X. Wu et al., 2022).

The first stage in the implementation of adaptive learning media is to conduct a comprehensive needs analysis. This analysis includes mapping pupils' characteristics, prior knowledge, learning barriers, access preferences, socio-emotional conditions, teachers' competencies, device availability, and internet connection quality. Teachers

need to identify pupils who require visual support, audio support, alternative text, repetition of material, step-by-step instructions, or enrichment challenges. The needs analysis must also involve special needs support teachers, parents and pupils to ensure that the information gathered is not derived solely from academic test results. This data forms the basis for determining the features, content types, level of adaptation, and form of support that must be provided by 'media'. This approach is crucial because media not grounded in real needs risks producing irrelevant adaptations or even reinforcing the labelling of pupils.

Once the needs analysis has been carried out, schools need to set learning objectives and the competences to be supported through adaptive media. Learning objectives must be clearly formulated so that the use of AI is not merely technology-oriented, but genuinely contributes to the attainment of pupils' competences. Teachers can identify specific subject areas most in need of adaptation, such as reading, mathematics, language, science or social skills. Each subject area is then mapped according to its level of difficulty, prerequisite competences, the types of errors that may occur, and alternative activities that can be provided. Setting clear objectives helps teachers assess whether the technology genuinely enhances pupils' understanding and independence. Furthermore, these objectives form the basis for selecting an AI platform, designing assessments, and determining indicators of successful implementation (Votto et al., 2021).

Implementation should ideally begin with a pilot study before being rolled out more widely. Schools may select a single subject, a single year group, or a specific group with particular learning needs as an initial phase. A limited pilot allows teachers and developers to identify technical errors, navigation difficulties, content mismatches, and pupils' responses to adaptive features. At this stage, schools can compare conditions before and after the use of the digital resources through assessment results, observations of engagement, interviews, and teachers' notes. The pilot also provides an opportunity for pupils to share their experiences of using the digital resources. Phased implementation is safer than immediate large-scale roll-out as it allows for a continuous process of evaluation and refinement (Hapinas et al., 2025). A strategy of phased integration and regular evaluation is also recommended when applying AI for inclusive learning.

Teachers play a central role in integrating adaptive learning tools into the learning process. Teachers act not only as users of the applications, but also as designers of learning experiences, supervisors of technology use, interpreters of data, and providers of social-emotional support. Recommendations provided by AI need to be reviewed in light of the teacher's knowledge of the pupils' circumstances. For example, the system may conclude that a pupil has not mastered a particular skill because they are making many mistakes, but the teacher may know that these mistakes are caused by a lack of concentration, language difficulties, or specific emotional circumstances. Therefore, learning decisions should not be left entirely to algorithms.

A hybrid approach combining human intelligence and AI is more suitable for personalised learning, as technology provides data analysis whilst teachers offer contextual and pedagogical considerations (Rosadi et al., 2026).

For implementation to be effective, teachers need training that focuses not only on technical skills but also covers AI literacy and inclusive pedagogy. Training should cover how the system works, the interpretation of learning data, the use of accessibility features, the development of adaptive materials, the verification of AI output accuracy, and the protection of pupil data (Kalantzis & Cope, 2004). Teachers also need to understand the limitations of algorithms, potential biases, and the risks of over-reliance on technology. Practical training can be delivered through workshops, classroom simulations, case studies, lesson plan development and individual mentoring. Training models that combine the practical use of text-to-speech, educational chatbots and adaptive learning platforms with the principles of UDL can help teachers apply AI more effectively in inclusive classrooms (Lee et al., 2011). Teacher competence is a key prerequisite, as advanced technology will not deliver benefits unless it is integrated with appropriate pedagogical strategies (Rozikin et al., 2024); (Osama et al., 2026).

The implementation of media must also take into account accessibility for students with various types of needs. Students with visual impairments require screen readers, alternative text, colour contrast, and voice- or keyboard-based navigation. Students with hearing impairments require transcripts, text, visualisations and captions in videos. Students with reading difficulties can be supported through text-to-speech features, font size adjustments, simplified language and less dense presentation of material. Meanwhile, students with concentration difficulties can benefit from material presented in shorter units, simple instructions and moderate reminders. Providing a variety of access options is in line with the principles of UDL, which emphasise diverse ways of engaging students, representing information, and expressing knowledge (Kalantzis & Cope, 2004). Consequently, accessibility must be an integral part of the design and implementation from the outset, rather than merely an afterthought once the media has been produced.

Adaptive learning media can be applied through several learning models. In individualised learning, students use the media to study the material at their own pace and according to their ability level. In group learning, teachers can use data from the media to form learning groups based on specific needs or competencies. In blended learning, adaptive media is used to complement face-to-face learning through reinforcement, remedial or enrichment activities (Mayer, 2002). Digital media can also be used prior to lessons to identify pupils' prior knowledge and after lessons to provide further practice. This flexibility enables teachers to combine technology with discussions, games, projects, experiments and social interaction. Effective implementation of AI does not isolate pupils in front of their devices, but helps teachers create more focused and meaningful learning experiences (Aslan, 2023).

The use of AI in inclusive education can also support more flexible assessment. Systems can provide diagnostic, formative and summative assessments with levels of difficulty tailored to pupils' abilities. Pupils can demonstrate their understanding through various formats, such as writing, speech, images, videos, multiple-choice questions, simulations or demonstrations. Flexibility in assessment formats is important because pupils' abilities cannot always be fairly measured through standardised written tests. AI can help identify patterns of errors, provide immediate feedback and recommend remedial materials (Mayer & Moreno, 2002). However, the results of automated assessments still need to be verified by teachers, particularly when assessments involve open-ended answers, language expression, alternative communication, or the performance of pupils with special educational needs. The use of AI-based assessment should be directed towards supporting pupils' development, rather than merely classifying or ranking them.

The learning dashboard is a key tool for monitoring the implementation of adaptive media. Through the dashboard, teachers can access information regarding student activity, completed material, levels of competence mastery, error patterns, use of assistance, and recommendations for follow-up. This information can be used to plan differentiated learning and provide more timely support to pupils experiencing difficulties (Mickhel & Thionuartha, 2025). However, the data on the dashboard needs to be presented in an easily understandable format and should not overwhelm teachers with too many indicators. Teachers also need to be aware of the limitations of this data, as not all aspects of learning can be measured through digital activities. Students' motivation, social relationships, self-confidence and emotional state still need to be observed through direct interaction. Consequently, the dashboard should be used as a supplementary source of information, rather than as a substitute for teachers' professional judgement (Osama et al., 2026).

The implementation of adaptive media requires collaboration between schools, teachers, pupils, parents and specialists. Parents need to understand the purpose of using the technology, the types of data collected, and how to support pupils when they use the media at home. General education teachers and special needs support teachers need to coordinate in interpreting the data and designing follow-up actions (Noor & Damariswara, 2022). Technology developers need to receive feedback from users so that the system is suited to local needs, language, culture and infrastructure conditions. Pupils also need to be given the opportunity to share their experiences, difficulties and preferences whilst using the media. Such collaboration is vital because inclusive education is a shared responsibility, not merely the task of teachers or application developers. The involvement of various stakeholders can also prevent media from being developed based on technical assumptions that do not correspond to pupils' real-life experiences (Nurhayati et al., 2023).

One of the main challenges in implementing adaptive learning resources is limited infrastructure and the digital divide. Not all schools have sufficient devices, a

stable internet connection, adequate electricity, or the technical support required to operate AI-based platforms. These conditions may result in the implementation of such resources primarily benefiting pupils in better-resourced environments. To address this issue, schools may consider lightweight platforms, offline use, the provision of downloadable materials, the sharing of devices, and the development of learning resources compatible with various types of devices. Implementation policies must also take into account families' financial circumstances and pupils' geographical circumstances. Equitable access must be a key indicator, as technology designed to support inclusion can actually widen the gap if it is not available evenly (Roemmich et al., 2023). Limitations in infrastructure and internet access have also been identified as significant barriers to the implementation of AI-based adaptive learning.

Further challenges relate to privacy, data security, algorithmic bias and system transparency. Adaptive learning platforms require student data to provide recommendations, but this data may include sensitive information regarding abilities, behaviour, special needs or health conditions. Schools must ensure that data collection is limited in scope, has a clear purpose, obtains appropriate consent, and is stored via secure systems. Furthermore, algorithms need to be tested to ensure that pupils from specific groups are not disadvantaged by the recommendations generated. The system must provide understandable information on how data is used and the factors influencing AI decisions. Rosadi et al., (2026) emphasise that the use of AI in education must be grounded in privacy protection, inclusion, equity, and human oversight. Therefore, the implementation of adaptive media must be accompanied by ethical policies and a complaints mechanism should students or parents find the system's decisions to be inappropriate.

Implementation should be evaluated comprehensively by combining quantitative and qualitative data. Quantitative data may include test results, task completion rates, frequency of media use, improvements in competence, and changes in student engagement scores. Qualitative data can be obtained through observation, interviews, teacher journals, group discussions, and the experiences of pupils and parents. The evaluation must also assess aspects of accessibility, ease of use, the appropriateness of AI recommendations, the quality of interaction, teachers' workload, and data security (Saputra et al., 2024). Quasi-experimental research in inclusive classrooms can compare the use of AI-based adaptive learning with conventional learning, but the results must be interpreted with caution as learning success is influenced by many factors. Evaluation should not focus solely on improved grades, but must also consider student engagement, independence, social interaction, self-confidence and participation in the learning process.

Ultimately, the implementation of AI-based adaptive learning tools should be understood as a process of pedagogical change that requires planning, collaboration, monitoring and continuous improvement. AI technology can help provide more personalised learning, support accessibility, detect learning difficulties at an early

stage, and assist teachers in managing heterogeneous classes. However, the success of implementation depends on teacher readiness, content quality, infrastructure availability, policy support, data protection, and the involvement of all stakeholders. Adaptive media should be used to expand learning opportunities, not to replace human interaction or reduce teachers' responsibilities. With ethical, inclusive and learner-centred implementation, AI-based adaptive learning media can serve as a strategic tool for realising an education system that is more flexible, equitable and responsive to diverse learning needs.

Conclusion

The development of AI-based adaptive learning media holds great potential in supporting inclusive education for pupils with diverse learning needs. This media can tailor content, difficulty levels, learning pace, presentation formats, activities and feedback based on each pupil's characteristics and development. Through the use of data analysis, machine learning, natural language processing, and accessibility features such as text-to-speech, speech-to-text, transcripts, visualisations and interactive materials, learning can become more personalised, flexible, accessible and responsive to differences in pupils' abilities.

The successful implementation of AI-based adaptive learning media depends heavily on the quality of pedagogical design, teacher readiness, the availability of infrastructure, and the involvement of pupils, parents and special educational needs experts. AI should not replace the role of the teacher, but rather serve as a supportive tool that helps identify learning needs, provide recommendations, offer feedback and monitor pupils' progress. Therefore, the development of such resources must be grounded in the principles of Universal Design for Learning, prioritising accessibility, offering a variety of material formats, and providing students with opportunities to learn and express their understanding in ways that suit their individual needs.

Although it offers numerous benefits, the use of AI in inclusive education also faces challenges such as the digital divide, limitations in teachers' digital competence, algorithmic bias, personal data protection, and the risk of over-reliance on technology. Consequently, the implementation of adaptive learning media must be carried out gradually, collaboratively, transparently, and sustainably through evaluation of academic, accessibility, engagement, socio-emotional, technical, and ethical aspects. If developed and implemented responsibly, AI-based adaptive learning tools can serve as a strategic innovation to create an education system that is fairer, more inclusive, personalised, and capable of accommodating the diverse learning needs of pupils.

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