

Adaptive Education, Viable Cognitive Frameworks, and Technological Innovation in Special Needs Education and Disability

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Abstract — *The United Kingdom is experiencing a significant rise in the prevalence of Special Educational Needs and Disabilities (SEND), with over 1.5 million students in England (17.3% of the school population) now requiring additional support. As of 2023, the number of pupils with Education, Health and Care Plans (EHCP) has increased by 5.6% year-on-year, reflecting a broader global trend of rising childhood disability. Despite the UK's sophisticated educational framework, the system faces critical lapses, including professional burnout among SEN staff and unsatisfactory educational outcomes for learners. The current system struggles to bridge the gap between rising demand and the delivery of inclusive, high-quality education, threatening both the well-being of the future workforce and the nation's long-term economic competitiveness. This paper argues for a strategic shift from viewing SEND support as a public expenditure drain to seeing it as a vital national investment. To optimize the school system, foundational reforms are required, specifically: integrating adaptive teaching methods (e.g., universal design, scaffolding, and flexible pacing) into Initial Teacher Training (ITT); mandating continuous professional development focused on sensory access and the removal of classroom micro-barriers; and reformulating school evaluation metrics to prioritize SEND inclusion indicators over general academic attainment. The study concluded that by addressing root causes and institutionalizing adaptive pedagogy, the UK can unlock the latent potential of SEND learners, ensuring sustainable returns on investment and a more resilient social structure.*

Keywords: *SEND; Education, Health and Care Plan (EHCP); Adaptive Teaching; Initial Teacher Training (ITT); Inclusion.*

I.INTRODUCTION

In England, reports show that out of the 9 million pupils/students in schools, more than 1.5 million of them have special educational needs, representing 17.3% of the schools' population; while between 2022 and 2023 alone, there was an addition of 87,000 to the number of pupils with an Education, Health and Care Plan (EHCP), representing a 5.6% year on year increase (GOV.UK, 2023a; GOV.UK, 2023b).

Across the United Kingdom (UK), there has been an increase in the number of children with special educational needs and disabilities, and these figures as the one cited for England, indicate that a substantial portion of the UK's future workforce could be significantly affected (GOV.UK, 2023a; GOV.UK, 2023b). It is important to look at the systemic challenges facing schools because of these changes, and to also make adequate preparations to forestall developments that could weaken the UK's robust and competitive social structure, and its pride of place as a global economic and political power.

Last year, SEN was reported to be most prevalent among boys at age 9 (23% of all boys), and for girls at age 10 (13% of all girls) respectively (Herwegen, 2022). Furthermore, autism is the most common condition reported among those with an Education Health and Care (EHC) plan across all ages from 4 to 17 (and therefore have autism-based needs), just as many others on Special Education Needs Support (SEN Support) primarily have Speech Language and Communication Needs (SLCN) (Herwegen, 2022). The global data too is worrying. As of 2022, the latest global data from the United Nations International Children Education Fund (UNICEF) showed that an estimated 266 million children between the ages 0 and 19 have moderate-to-severe disabilities based on household surveys on child functional status (Olusanya et al, 2022). This data consists of 28.9 million (4.3%) children between ages 0–4 years, 207.4 million (12.5%) children aged 5–17 years, 236.4 million (10.1%) children aged 0–17 years, and invariably leaving 29.6 million teenagers between ages 17 and 19 years who have moderate-to-severe disabilities (Olusanya et al, 2022).

The realities of these developments show that there is not only a need to investigate the root causes of these developments, but to also adapt and optimise the school system to ensure it caters to the needs of learners with SEND so as to supply the vital

intellectual, academic and life skills they need for their immediate, intermediate, and long-term well-being.

II. UNDERSTANDING THE IMPORTANCE OF ADAPTIVE EDUCATION

Adaptive education is a paradigmatic approach to education which recognises that each child has unique abilities, interests, backgrounds, and learning styles, and as a result teaching methods and curriculums are tailored in ways that are responsive to the diverse learning needs of pupils (Ellis et al, 2017; Westwood, 2018; Adewusi et al, 2023). The aim of adaptive teaching and education is therefore to create inclusive and responsive learning environments that cater to these different needs (Adewusi et al, 2023). In the context of this study, adaptive education is an inclusive educational approach that adjusts pedagogical approaches, educational materials, and learning assessment measures to reflect the individual profiles of learners, especially for learners with special educational needs and disabilities (SEND) (Mould, 2021). This way, cognitive micro-barriers in classroom learning can be removed, and then SEND professionals in the schools can also work with other stakeholders to optimise the learning experience and also improve the quality of education accessible to those learners with disabilities or learning difficulties (Athanasaki et al., 2007).

Some of the most outstanding theoretical pillars for the adoption of adaptive education include: the constructivist's view that posits that learners play active roles in constructing their understanding of the world; the conception of a person's multiple intelligences in respect to humanity's distinct range of intelligences such as linguistic, logical-mathematical, spatial, and interpersonal intelligence; and the importance of nurturing socio-emotional development especially in young learners (Ainsworth, 1990; Karen, 1998; Allix, 2000; Kalina & Powell, 2009; Davis et al, 2011; Babakr, Mohamedamin, & Kakamad, 2019; Adewusi et al, 2023). Another vital theoretical underpinning is the school of thought that canvases nurturing the Zone of Proximal Development (ZPD) of the learner, and using the strategy of scaffolding through which learners are introduced to and supported to learn things beyond their immediate level of competence, so as to initiate appropriate challenges and guidance

for their learning progress (Shabani, Khatib, & Ebadi, 2010; Mcleod, 2022; Adewusi et al, 2023).

In practical application, there are key strategies in adaptive education that make it effective. At the cornerstone of its effectiveness is the importance of *differentiated instruction* which tailors educational activities to meet the diverse needs of learners in the same classroom through methods like *formative assessments for learning*, *flexible grouping* (e.g., small group instruction, peer tutoring, one-on-one sessions), *adjustable pacing* (managing differentials in learners' progress by pacing instruction to support those requiring additional time as well as accommodating those ready for advanced challenges), and the use of *varied learning materials* (such as visual aids and hands-on items) that create opportunities for pupils to engage educational content in ways that align with their individual flairs (Sullivan & Weeks, 2018; Zafiri, Konstantinidou, & Pliogou, 2019).

Other applicative strategies include the use of Project-Based Learning (PBL), Personalized Learning Plans (PLPs), Play-Based Learning, Scaffolding and Guided Discovery, Culturally Responsive Teaching, Outdoor and Nature-Based Education, Social and Emotional Learning (SEL), Technology Integration, and quite importantly—the adoption of Universal Design for Learning (UDL) which emphasises diversity of content formats (i.e., text, visuals, audio, and tactile materials), effective accessibility to understandable information by all pupils, different classroom engagement measures (based on interests, motivations, and cultural backgrounds), and varied forms of assessment as a recognition that children show their understanding differently (Macy, 2016; Dalton, 2017; Winter et al, 2019; Hoffmann et al, 2020; Shemshack & Spector, 2020; Bishop et al., 2021; Boss & Krauss, 2022; Cade, Wardle, & Otter, 2022; Adewusi et al, 2023).

This adaptive form of education has gained increasing prominence and has been adopted by countries like the UK as a global best practice, as evidenced by the domestication of its principles in the SEND Code of Practice (2015). However, a major criticism of adaptive education is the argument that when children or students visibly use different educational materials or technological platforms from those of their peers, its unintentional effect is that there is a more pronounced sense of difference or

demarcation that can negatively impact their self-image (Garrison, 2020). To address this concern, it is important to clarify that education that is truly inclusive will normalise diverse learning paths and will foster practical classroom sessions in which “just-right-challenges” are provided for every pupil (Pane, Steiner, & Key 2017). This way the focus shifts from the concern of learners with special needs or disabilities feeling different, to the more agreeable context of personalised learning, with everyone being on their own unique and successful learning path (Pane, Steiner, & Key 2017).

However, it is posited here that despite the strong counter argument of personalised learning, we must realise that early learners do not have the sophistication to adequately reflect this point of view, and as a result, stakeholders and professionals need to ensure that differentiation in content is used under a proficiently nurturing atmosphere and introduced in such a subtle and integrated manner that the unintended likelihood of amplifying difference is reduced to insignificant proportions or successfully eliminated altogether. There is also the reported concern that the regular algorithms used in the efforts at adaptive education might oversimplify the complexities a child with SEND has, such as streamlining to a narrow set of academic skills for instance, and thus missing vital social, emotional, sensory, or developmental needs, and eventually leading to an incomplete educational plan (Holmes et al., 2019).

It is not advisable to remove these algorithms, instead they can be enhanced to reflect a more holistic frame of assessments in line with both national objectives and the best adopted standards for educational development. As Hwang et al. (2020) have noted in a different study, algorithms are most effective within the context of holistic assessment frameworks, because they create a template for data gathering and objective insights into the learning patterns of pupils and students. This helps teachers identify skill gaps and grey areas learners have in respect to concepts they are being taught, thus the teacher’s role is more informed, strategic and effective. But beyond these concerns on creating unintended difference and narrow algorithms, another major area in which criticisms to adaptive education have arisen is in respect to technological innovation and the associated challenges.

There are concerns that reliance on technology-based learning platforms can isolate children with SEND from their peers and teachers, and that this could impede their social-emotional development (Rose & Meyer, 2002; Kruse et al., 2017). There are also worries that increased technological adoption can create problems of digital divide (in terms of affordability, accessibility, and ability to operate the technology), while also astronomically raising implementation costs in terms of structural/systemic expenditures, training expenses, and the cost of technological hardware acquisitions and software licenses (Zawacki-Richter et al., 2019; E-Learning Industry 2021). In respect to the tendency for technology to create isolation, it is important to state that the essential purpose of technology adoption in adaptive education is not to replace human teachers and peer interaction, but to rather support them and optimise their impact (Bishop, Downes, & Farber, 2021; Muñoz Martínez & Porter, 2020). By automating individualised aspects, teachers are better able to focus on meaningful group and one-on-one engagements with their pupils and therefore preserve social-emotional development (Luckin et al., 2016).

The questions arising from technological divide and cost essentially have to do with policy implementation measures rather than the substantive value and principles of adaptive education, and this is important to mention because the adaptive model can be implemented with low-tech initiatives/tools or even non-tech initiatives/tools (Rose & Meyer, 2002; World Bank, 2018). However, it is the view of this study that it is important to adopt the most strategic and most efficient use of resources, ensure collaboration with technologists to foster ease of technological use, and to view the entire process as an indispensable and worthy investment in the future of children and that of the country. More so, the initial high technological costs will diminish as producers break even and when open-source options become available. Technology is itself a lever that helps teachers to streamline workflows and curtail the repetition of ineffective activities, which over time also reduces the cost of remedial interventions (Kruse et al., 2017).

III. VIABLE COGNITIVE FRAMEWORKS

Flowing from the above understanding of adaptive education and its inclusive value for SEND learners, evidence shows that traditional ability-grouping methods can in some cases be counter-productive,

and even when successes are recorded, the impact seems to only be marginal (Leswell, 2025). Thus, adaptive education with its personalisation and in-class support outlook is a more effective option that can even be further optimised through assistive technological devices, however, it is crucial to point out that the learner's mental action and how they process and understand knowledge (i.e., cognition) is a fundamental aspect that the educator must be concerned about to maximise the children's exposure to learning (Sweller, 2011). It is for this reason that six of the most recognised and supportive cognitive frameworks are discussed below.

- **Universal Design for Learning (UDL):** This framework is built on three core principles (DfE Advisory & Caldwell, 2020). (i) *Multiple means of representation* to address diverse needs in terms of learners' sensory, perceptual, and cognitive processing, and presents information in various formats, i.e., auditory, visual, and tactile. This helps learners with specific learning difficulties, sensory impairments, and autism spectrum disorders (ASD). (ii) *Multiple means of engagement* to stimulate interest, motivation and address emotional regulation challenges for children with attention deficit/hyperactivity disorder (ADHD), autism, and emotional/behavioural difficulties. This principle encourages flexibility of choice in learning environment, topics, and tools. (iii) *Multiple means of action or expression* as a way of recognising diversity in how learners demonstrate knowledge, understanding and skills. As a result this principle accommodates different motor and communication skills, and executive function abilities, making UDL suitable for learners with physical disabilities, communication disorders, and dysgraphia.

- **Cognitive Load Theory (CLT):** This theory emphasises managing the working memory load of a learner in the most effective way for the purpose of identifying specific strengths and limitations (Sweller, 2011; Sundararajan & Adesope, 2020). It emphasises structure, simplification, chunking, and variability in presentation, and in turn makes teaching and learning more effective for SEND learners such as those with autistic, dyslexic, and ADHD profiles among other special needs/disabilities (Sweller, 2011; Sundararajan & Adesope, 2020). In relation to learners with SEND, there are three major cognitive load factors to consider, i.e., managing *intrinsic load* (which is vital for learners with intellectual

disabilities and specific learning difficulties in order to help them deal with the inherent difficulties of learning materials and to carefully manage them through task analysis and scaffolding), managing *extraneous load* (which involves reducing cognitive burdens imposed by poor instructional design and is essential for learners with concentration difficulties and processing disorders), and managing *germane load* (which is devoted to managing load that involves processing and schema construction and must be optimised to support effective and meaningful learning for learners with memory or executive function challenges).

- **Response to Intervention (RTI) / Multi-Tiered Systems of Support (MTSS):** This cognitive framework provides a systematic approach to identifying the varying levels of needs of learners with SEND and provides a three-tiered system to address them (Choi, et al., 2023). This tiered approach includes: *universal quality instruction* (the first-tier which uses UDL principles and preventive approaches to provide universal high-quality instruction, and then forms the foundational basis to identify learners needing additional support); *targeted small-group interventions* (which is the second-tier and it focuses on tackling learning difficulties through small-group interventions by using evidence-based practices for learners identified to be at risk, so as to ensure data-driven decision-making and progress monitoring); and *intensive individualised support* (the third-tier in the system and which involves collaboration with general and special education professionals for the purpose of carrying out comprehensive evaluation of learners with significant needs and providing individualised planning and specialised interventions for them).

- **Zone of Proximal Development (ZPD) Framework:** This framework is particularly adopted to help learners with developmental delays and learning disabilities, and it is usually implemented using the scaffolding method so as to close the gap between what these learners can achieve independently as against what they achieve through the guidance of a teacher or a peer who is proficient in the specific task (Bernacki et al, 2021). The learner is thereby able to distinguish between their current capabilities and their potential growth, thus creating an appropriate level of challenge to spur learning and the attainment of new capabilities (Bernacki et al, 2021). This creates two essential steps in the ZPD

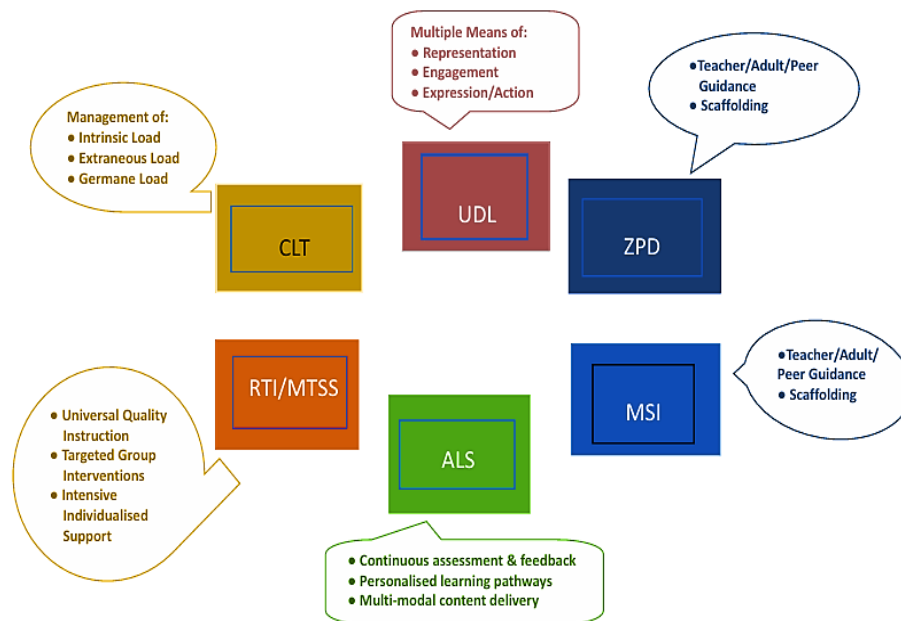
framework, i.e., *teacher/adult/peer guidance* which reveals the potential for growth, and *scaffolding* which helps to spur learning in order to close the gap and thus attain a new level of growth/development.

- **Metacognitive Strategic Instruction (MSI):** This cognitive framework dwells on the need to get learners to think about their own thinking, i.e., self-evaluation of their thought processes (Donker, 2018). This is to help them develop *strategy awareness* (through training on when and how to use certain strategies, an approach that is very useful in helping children with autism), *strategy monitoring* (helping them self-regulate in evaluating strategy effectiveness especially for those with ADHD and attention difficulties), and *strategy generalisation* (training them on applicability of learned strategies across different contexts and subjects, which is a vital skill for long term academic/life success) which over the years has been shown to boost performance of learners and those with SEND (Donker, 2018).
- **Adaptive Learning Systems (ALS):** This cognitive framework deals more with the teaching and assessment modality to be adopted, and it emphasises the use of data-driven instruction to adjust and tailor learning experiences to cater to the

identified needs of learners (Bernacki et al, 2021). The ultimate contribution of this cognitive approach is that actual data from the engagement, performance and progress of the pupils/students is assessed and interpreted for the purpose of providing appropriate individual support to those who need it. It encapsulates and reinforces the idea of adaptive education with an amplified focus on using assessment data to drive decision-making in the education process (Bernacki et al, 2021).

It can be deduced that ALS is implemented through three main thrusts: i.e., *continuous assessment and feedback* (which involves monitoring the learner’s real time progress for appropriate adjustment of difficulty level of presented content), *personalised learning pathways* (which emphasises alternative routes to learning objectives and individual progression based on personal mastery of personalised content), and *multi-modal content delivery* (which encourages integration of assistive technologies and automation of content adjustment based on learner’s needs). ALS can help cater to learners with diverse SEND profiles and abilities, differences in learning and processing rates, and those with sensory impairments and communication disorders.

Figure 1: Viable Cognitive Frameworks



IV. AN OVERVIEW OF THE IMPORTANCE OF TECHNOLOGICAL INNOVATION IN TEACHING LEARNERS WITH SEND

As earlier noted, an essential part of adaptive education will be the integration of assistive technologies as useful levers towards the achievement of SEND learner outcomes. However, in view of the expressed concerns on machines

replacing humans and its potential to negatively impact the vital social-emotional connection that teachers and the school setting provide, it remains to be seen to what extent that the disruptive tendencies of digital technologies like artificial intelligence can alter the school system as we currently know it. However, it is the position of this paper that the role and place of humans in the teaching and guidance process for learners with SEND is fundamental in the doubtful circumstance that machines will be able to replace the intuitive, interpretive, and nuanced social skills and emotional intelligence that a human teacher brings to the table. Nonetheless, this does not remove the indispensable value of assistive technologies in achieving an intelligent, effective, and adaptive educational system.

Some of the key technological considerations should include both low-tech (like overlays and grip aids) and advanced assistive tools (such as text-to-speech, speech-to-text, augmentative and alternative communication (AAC) devices; Adaptive Learning Platforms; AI-based Intelligent Tutoring Systems (ITS); Augmented Reality and cloud-based systems. As technological breakthroughs are made, it is only natural that stakeholders in the education industry collaborate with technologists to enhance assistive technologies that meet the desired standards and ease of operability.

V.CONCLUSION

Despite the level of sophistication of the UK's education system, and its significant efforts are inclusive adaptation, reports show that in respect to children with SEND, the system has gaping lapses that limit the quality of education accessible to this set of learners, there is also increased burnout among SEN professionals within the system, and these are reflected in the unsatisfactory educational outcomes and loss of critical manpower (Herwegen, 2022; Kelly, 2022; Brunsting et al, 2023; UK Department for Education, 2023).

This is why deliberate efforts must be deployed to first address the root causes of this spike. There is also a need to recruit more hands and optimise the adaptation of the school system in relation to learners with SEND and maximise the latent potentials of this category of learners in respect to specific metrics that are pedagogically, socially and economically sound. Without this, the hullabaloo and concerns about the heavy cost to public expenditure will continue to feel

like a melancholic drain with hushed retorts due to the sensitive nature of the subject. However, the right perspective will make these efforts a rather strategic indispensable investment with clear national objectives and unquantifiable returns on investment.

It is also canvassed here that for adaptive teaching to be better entrenched in the mainstream UK school system, there is a need to take foundational steps that integrate training in adaptive teaching methods right from the Initial Teacher Training (ITT) programme. Early inculcation of adaptive teaching methods like universal design principles, scaffolding, and flexible pacing, among others, can go a long way to help teachers to be more innovative and inclusive in their teaching. It is also important for regulators to mandate continuous professional development for teachers in relation to adaptive teaching measures and reduction of micro barriers such as class layout and sensory access. SEN outcomes can then be a basis to evaluate schools on vital SEND inclusion indicators rather than regular or general attainments.

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