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Agentic AI in STEM Education: Enhancing Cognitive Flexibility and Workforce Readiness

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Abstract: *This scientific article examines the transformative potential of Agentic AI in Science, Technology, Engineering, and Mathematics (STEM) education. It highlights how Agentic AI can enhance learning outcomes in these subjects, reduce cognitive load, and better prepare students for the demands of an AI-driven workforce. By utilising smart tools like GitHub Copilot, Agentic AI systems provide opportunities to improve STEM learning environments through personalised assistance, collaborative problem-solving, and skill development, all while automating repetitive tasks. This paper also discusses the future implications of the job market influenced by Agentic AI, emphasising the need for upskilling and the necessity for educational systems to adapt to emerging roles. It also touches on ethical aspects like fair access and AI literacy while highlighting how Agentic AI could help bridge the gap between traditional education and real-world job readiness.*

Keywords: *agentic AI; STEM education; AI-driven learning; cognitive load reduction; personalised learning; labor market impact.*

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1. Introduction

Advancements in artificial intelligence (AI) are transforming educational practices globally, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM) (Chassignol et al., 2018; Zawacki-Richter et al., 2019). Among various AI paradigms, "Agentic AI" systems—characterized by autonomy, context-awareness, and decision-making abilities—show great potential in fostering adaptive and personalized learning environments. These systems can automate tasks, provide feedback, and tailor challenges to meet individual student needs, aligning with broader trends toward inclusive and learner-centered educational practices (Holmes, Bialik, & Fadel, 2019).

STEM education can greatly benefit from Agentic AI solutions. By reducing cognitive load and providing on-demand support—similar to how GitHub Copilot assists in computer science education—Agentic AI allows learners to concentrate on advanced problem-solving and critical thinking. There is substantial evidence indicating that the integration of AI-driven tools helps bridge the gap between academic curricula and the skills needed in the labor market (World Economic Forum, 2023). In STEM fields, AI-enhanced software environments can encourage collaborative problem-solving skills, foster deeper engagement, and offer instant formative feedback, all of which are essential for developing workforce talent that is resilient in an adaptive labor ecosystem.

The potential of Agentic AI in STEM education demands addressing challenges related to ethics, equity, and appropriate educational practices as biases, AI literacy, and infrastructure prerequisites are present to prevent the unintended exclusion of marginalised learners (Holmes, Bialik, & Fadel, 2019; Zawacki-Richter et al., 2019). Moreover, the transition to a workforce that AI technologies have shaped underscores the need for current education systems to equip learners not only with computational competencies but also with adaptive, interdisciplinary skills (World Economic Forum, 2025).

In this article, the authors examine how Agentic AI tools can reshape STEM learning experiences and facilitate job readiness, with a particular emphasis on GitHub Copilot as an example of AI-driven collaboration in coding education. Also, a discussion is needed for the emerging roles and skill sets triggered by these technologies, along with ethical and practical considerations that education stakeholders must address to ensure sustainable and equitable AI adoption.

2. The Role of Agentic AI in STEM Education

Unlike traditional AI-driven educational tools, which primarily function as static content generators or recommendation engines, Agentic AI systems engage in iterative reasoning and contextual decision-making, continuously adapting based on user interactions (Russell & Norvig, 2020).

In STEM education, where students are required to solve complicated, open-ended problems, this distinction is essential. The capacity of agentic AI to independently modify its teaching tactics in real time is consistent with new pedagogical paradigms that prioritise competency-based, individualised learning (Collin, Lepage, & Nebel, 2024). These AI systems can act as intelligent collaborators rather than passive content suppliers by utilising contextual awareness and iterative planning, radically altering how students learn.

Apart from academic viewpoints, the industry perspective is also extremely significant. A system that "uses sophisticated reasoning and iterative planning to solve complex, multi-step problems autonomously" is what Pounds (2024) refers to as agentic AI. This concept emphasises the fundamental qualities of agency in AI systems, such as the capacity for independent decision-making and goal pursuit without human assistance. We can better comprehend how Agentic AI functions in practical applications by combining the viewpoints of academia and industry.

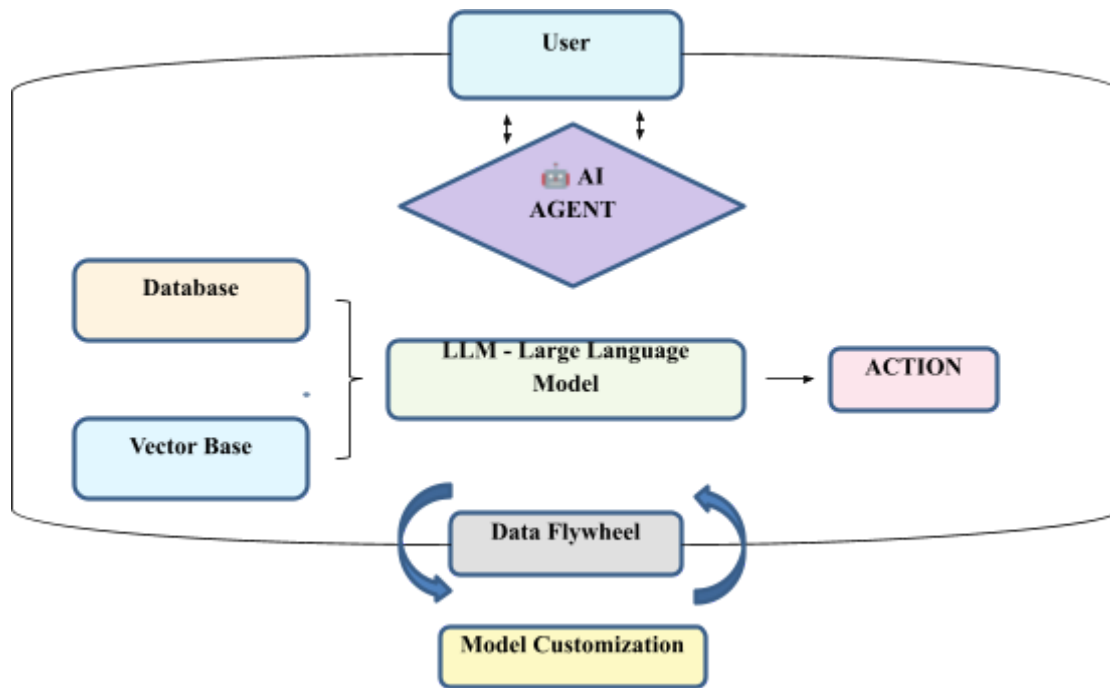


Figure 1. Nvidia Agentic AI definition

User (Light Blue): The starting point is when the User engages directly with the AI Agent. AI Agent (Light Purple): Central hub processing inputs and orchestrating outputs. Database (Light Orange): Stores structured data for analysis. Vector Database (Light Blue): Handles unstructured data for deeper insights. LLM (Light Green): The core engine that analyses input and generates actions. Action (Light Pink): The response generated by the LLM is based on the input. Data Flywheel (Light Gray): Represents the feedback loop, enhancing the model over time.

These AI systems are not merely tools but act as agents that can execute tasks, make decisions, and interact with their environment in an advanced, often human-like manner. According to Floridi and Sanders, agentic AI involves “interactive, autonomous, and adaptive” agents, where autonomy implies that “the system can change its state without direct response to interaction”. While agentic AI has goal-directed behaviour, which enables it to dynamically produce and revise solutions based on student needs, conventional AI tools frequently rely on fixed rules or predetermined algorithms to govern learning.

In STEM education, where students are required to solve complicated, open-ended problems, this distinction is essential. The capacity of agentic AI to independently modify its teaching tactics in real time is consistent with new pedagogical paradigms that prioritise competency-based and individualised learning.

The benefits of computational tools in teaching and e-learning, particularly within the fields of science, technology, engineering, and mathematics, are extremely relevant as these tools can help the students to visualise complicated concepts, receive prompt feedback, and develop crucial analytical skills. When combined with supportive instructional strategies, they encourage in-depth exploration of concepts and, in some cases, an expanded sense of self-efficacy among learners (Holmes, Bialik, & Fadel, 2019).

While traditional software solutions provide pre-scripted tutorials or static feedback, new systems shift toward more autonomous solutions capable of rapidly adjusting to individual needs. This shift reflects a broader aim to reduce barriers associated with coding tasks and allow students to focus on high-level problem-solving.

Autonomous computational systems, referred to as “agentic” applications, can operate with a heightened level of independence, making decisions or recommendations based on context and user input. Within an educational setting, these features can potentially offload routine tasks, such as code debugging, and provide more immediate support for a variety of assignments.

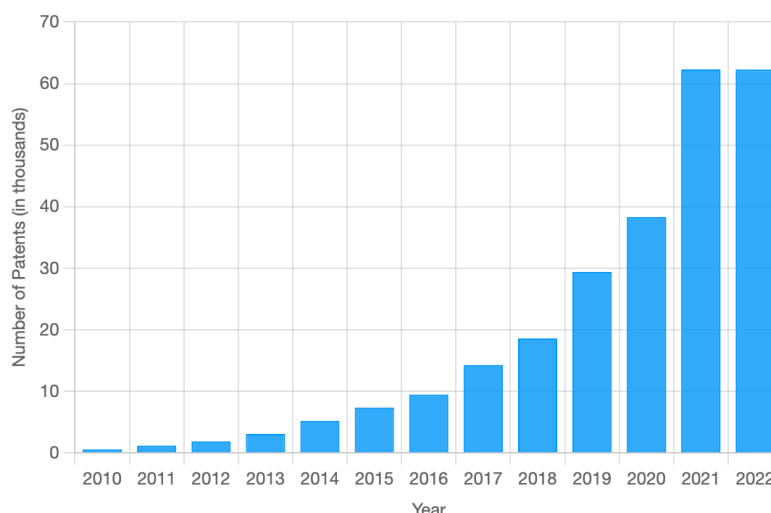


Figure 2. The global increase in AI patents awarded from 2010 to 2022

In the early 2010s, growth was steady but moderate, with a 56.1% rise between 2010 and 2014. More recently, the AI patent reached a 62.7% year-over-year increase in 2022, progressing at a faster pace than the development of AI governance frameworks.

3. GitHub Copilot as a Learning Tool and Developer Perceived Productivity

GitHub Copilot, an AI-powered coding assistant, exemplifies the potential of Agentic AI in STEM education. By generating code, suggesting solutions, and assisting with debugging, Copilot reduces the cognitive load on students, allowing them to focus on understanding core concepts and solving complex problems. It also enables real-time collaborative coding, intelligently adapting to the dynamic requirements of projects, thereby enabling developers to increase efficiency and adaptability in software development.

GitHub Copilot has helped developers work more efficiently and made their jobs less stressful in many organisations. By suggesting code snippets based on context, it has led to a 10.6% increase in pull requests on average and reduced cycle times by about 3.5 hours. These improvements show how it simplifies software development and makes the process smoother.

To better understand the real-world impact, a study involving over 2,000 developers found that GitHub Copilot was found to be extremely easy to use by 43% of the participants, and 51% rated it as extremely useful.

Table 1. GitHub Copilot Adoption - Survey on Perceived Productivity

#	Category	Statement	Percentage
1	Perceived Productivity	I am more productive	88
2	Satisfaction and Well-being	Less frustrated when coding	59
3	Satisfaction and Well-being	More fulfilled with my job	60
4	Satisfaction and Well-being	Focus on more satisfying work	74
5	Efficiency and Flow	Faster completion	88
6	Efficiency and Flow	Faster with repetitive tasks	96
7	Efficiency and Flow	More in the flow	73
8	Efficiency and Flow	Less time searching	77
9	Efficiency and Flow	Less mental effort on repetitive tasks	87

The quick adoption rate, with 81.4% of developers installing the Copilot IDE extension on the same day they received a license, led to a 15% increase in the pull request merge rate.

The research highlighted the system's effect on developer satisfaction, with the majority reporting significant reductions in mental effort during repetitive tasks, while this enhancement in job satisfaction and the decrease in cognitive load contribute to long-term benefits for developers and companies, it can significantly reduce burnout and promote a more productive work environment.

In academic environments, this shift changes the focus from just technical skills to a broader approach that includes problem-solving, creativity, and critical thinking. In the workplace, it reflects the increasing demand for professionals who can adapt, make good use of digital tools to work more efficiently, and stay relevant as industries change.

4. AI Integration in STEM Education: A Case Study of Carnegie Learning's MATHia

Agentic AI tools help students focus on solving problems rather than just writing code. They make it easier for beginners to get started while also helping experienced developers improve their skills.

AI-powered platforms are becoming more common in education, helping to personalise learning, keep students engaged, and provide instant feedback. One example in STEM education is Carnegie Learning's MATHia, a tutoring system designed to offer personalised and adaptive math instruction based on research. By leveraging cognitive science and AI, MATHia exemplifies how AI can enhance learning experiences, support individualised instruction, and address students' unique learning needs in preparation for future STEM careers.

MATHia is an AI-driven adaptive learning platform that provides individualised mathematics instruction to middle and high school students. Developed by Carnegie Learning, MATHia utilises ML and cognitive modelling to adapt content to each student's needs in real time. Unlike traditional education, which follows a well-established curriculum, it continuously adjusts the difficulty, adapted to student interactions.

The application is grounded in cognitive learning theory and artificial intelligence-driven adaptive learning as the system is built upon Carnegie Learning's Cognitive Tutor software, initially developed by researchers at Carnegie Mellon University, which was informed by Anderson's Adaptive Control of Thought-Rational (ACT-R) theory of cognition. This model proposes that human thought processes work through knowledge tracing, where learners transition from declarative to procedural knowledge through repeated practice and feedback.

MATHia's underlying AI technology integrates principles from computational neuroscience, allowing it to track students' cognitive load and adjust problem complexity to enhance working memory efficiency and promote long-term retention.

Academic research has demonstrated that AI-based adaptive learning systems significantly improve student outcomes by tailoring instruction to their cognitive needs.

Empirical studies evaluating AI-based mathematics platforms, including MATHia, indicate that students using intelligent tutoring systems (ITS) demonstrate more significant gains in algebra and geometry than those receiving conventional classroom instruction alone. These studies highlight:

1. Higher accuracy rates in solving multi-step problems among students who engaged with AI-driven learning environments.
2. Improved retention of mathematical concepts, which is reflected in better performance on cumulative assessments.
3. Students demonstrate greater engagement and perseverance in solving complex problems as they receive targeted scaffolding instead of generic instruction.
4. Students using MATHia show improved skills in algebra and geometry, resulting in better problem-solving accuracy and conceptual understanding.

5. AI-driven reinforcement in MATHia enhances students' retention of mathematical concepts, as spaced repetition and active problem-solving strengthen neural pathways for learning.

This case study illustrates the transformative potential of an AI-driven mathematics education system that integrates cognitive science principles and intelligent tutoring technologies to improve both conceptual understanding and procedural literacy.

Feedback systems have been demonstrated to enhance students' problem-solving skills by providing targeted guidance on errors and preventing common misunderstandings. Real-time assessment adjustments ensure that learners are challenged appropriately, at the right time and level. The knowledge tracing algorithms and adaptive feedback mechanisms make MATHia a highly customized learning experience that aligns with modern pedagogical research and the concept of hyper-personalized user experience (H UI/UX).

GitHub Copilot is a significant example of Agentic AI in computer science education, but similar AI-driven tools are transforming learning in other STEM fields as well. For instance, AI-powered systems like AlphaFold are accelerating the prediction of protein structures in biology. This advancement enables students and scientists to explore molecular interactions with unprecedented accuracy.

AI-enhanced computational solvers as Wolfram Alpha and MATLAB's deep learning frameworks, give students real-time analytical capabilities in physics and engineering and environmental science artificial intelligence-driven systems, like ClimateAI, are giving students predictive modelling tools to examine ecological data and evaluate climate changes. Agentic artificial intelligence already shows across STEM disciplines its capacity to support inquiry-based learning and improve student involvement.

Addressing challenges related to "teacher integration", equity, and student autonomy, it remains important to ensure that AI serves as a pedagogical tool rather than being promoted for commercial interests as a "replacement" for human interaction. Future research should focus on strategies for enhancing the interpretability of AI-generated learning insights for both teachers and students.

5. Workforce Preparation and Skill Development Using Agentic AI

Preparing students for the AI-driven workforce means rethinking education as industries like finance, healthcare, and technology increasingly rely on Agentic AI. As AI reshapes the job market, future workers will need skills that blend technology with insights from neuroscience. AI-powered learning, adaptive teaching methods, and digital tools are already changing the way people develop expertise in STEM fields. The World Economic Forum predicts that AI will significantly transform 23% of global jobs in the next five years. To keep up, STEM education must adapt, ensuring students understand AI systems and how to apply them in real-world settings.

The World Economic Forum and Accenture white paper titled "Jobs of Tomorrow: Large Language Models and Jobs" addresses that the transformative role of large language models (LLMs) is expected to reshape the labour market and the future of work. This analysis is relevant in understanding the implications of integrating agentic artificial intelligence (AI) into industries by examining over 19,000 tasks across 867 occupations, offering a structured perspective on how LLMs influence job workflows, create new opportunities, and change established roles.

The research outlines that 23% of global jobs are projected to change in the next five years as industries adopt AI-driven technologies. At the core of this transformation is the capacity of LLMs to dramatically automate routine and repetitive tasks, such as data entry, document verification, and clerical work. Jobs like Credit Authorisers, Management Analysts, and Statistical Assistants, work fields with high exposure to repetitive workflows, are prime candidates for automation.

However, the role of LLMs goes beyond displacement, as they can significantly enhance the potential of more complex and abstract jobs. For example, roles that require deep reasoning, human

creativity, and collaborative problem-solving, such as those in scientific analysis or software development, are likely to be augmented.

Historically, technological innovation has led to many disruptions but has also brought new roles and industry opportunities. In this sense, education and other high-exposure industries stand to benefit from the rise of emerging job categories powered by LLM adoption. For example, entirely new professions, such as AI Prompt Engineers, Data Curators, Interaction Designers, and Ethics/Governance Specialists, demonstrate the evolving needs of an AI-driven organisational structure.

Nevertheless, the labour market shifts brought by LLMs are not uniform. The financial services sector is among the most exposed to these technologies, with an estimated 70% of working hours at risk of being impacted. For roles that involve customer-facing interactions, such as client management or fraud detection, AI tools offer augmentation rather than pure replacement, automating some processes while enabling specialists to engage in other problem-solving tasks.

The rapid adoption of LLMs does raise concerns about employment security, socioeconomic disparities, workforce readiness, and the relevance of current educational programs and upskilling necessities. The report highlights the need for relevant education and workforce development initiatives, including cross-skilling programs and lifelong learning systems, to prepare employees for new professional roles. Companies are called upon to align their internal workforce planning and upskilling strategies to responsibly manage transitions, increase efficiency, and maximise the benefits of generative AI technologies.

Table 2. GitHub Copilot Adoption - Survey on Perceived Productivity

Occupations	Exposure %	Augmentation	Lower Potential	Non-language Tasks
Credit Authorisers, Checkers, and Clerks	81	7	12	
Management Analysts	70	7	24	
Telemarketers	68	18	13	
Statistical Assistants	61	1	34	7
Tellers	93	4	37	
Forensic Science Technicians	60	1	4	37
Receptionists and Information Clerks	58	11	31	
Brokerage Clerks	58	16	17	10
Production, Planning, and Expediting Clerks	57	15	18	10
File Clerks	56	7	11	26
Word Processors and Typists	55	5	40	
Bookkeeping, Accounting and Auditing Clerks	55	23	22	
Legal Secretaries and Administrative Assistants	54	23	12	11
Loan Interviewers and Clerks	54	27	13	7
Bill and Account Collectors	53	9	21	17

The study highlights that LLMs can impact roughly 80% of the workforce, with tasks being completed up to 15% faster at similar quality and rising to 47-56% with specialised software. It is important to point out that LLMs may automate specific tasks, and they also augment many roles, particularly those requiring critical thinking and problem-solving skills. In STEM fields, where

these skills are essential, integrating LLMs into the curriculum can prepare students for future job markets that increasingly rely on AI technologies, including developing competencies in data analysis and programming.

STEM education must evolve to include training in these emerging fields, ensuring that students are equipped with the skills necessary for future employment opportunities. The workforce of the future is being shaped by technological advancements, particularly artificial intelligence (AI), coupled with insights from neuroscience.

Neuroscience highlights the importance of cognitive flexibility, the ability to adapt to new information and changing environments in preparing students for the new ways of working. Agentic AI provides adaptive learning experiences that challenge students to think critically and collaborate. For example, AI can assess student performance, pinpoint areas that need improvement, suggest personalised learning paths, and adjust assignment difficulty on the spot. This dynamic approach not only enhances learning outcomes but also equips students with the cognitive flexibility needed to thrive in an AI-driven economy. As Agentic AI becomes more prevalent in education, ethical considerations must be addressed – such as Bias Management - to ensure equitable access and responsible use, making sure that all students, regardless of socioeconomic background, have access to AI-driven learning tools.

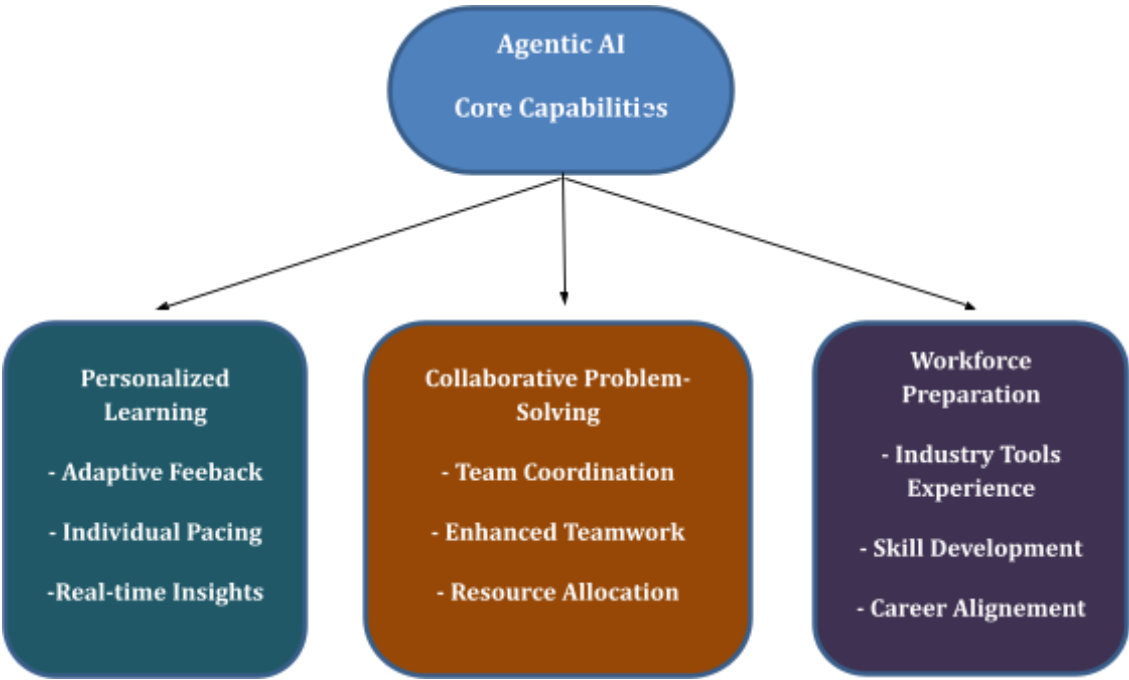


Figure 3. The Role of Agentic AI in STEM Education

6. The Role of Cognitive Flexibility in Agentic AI Workforce Preparation: A Neuroscientific Perspective

Today’s neuroscientific research underscores the critical role of cognitive flexibility in equipping students for the demands of a rapidly evolving workforce. Cognitive flexibility, defined as the ability to shift between different concepts, adjust to new information, and modify behaviour in response to changing environmental demands, is a key executive function governed by the prefrontal cortex (Braem & Egner, 2018).

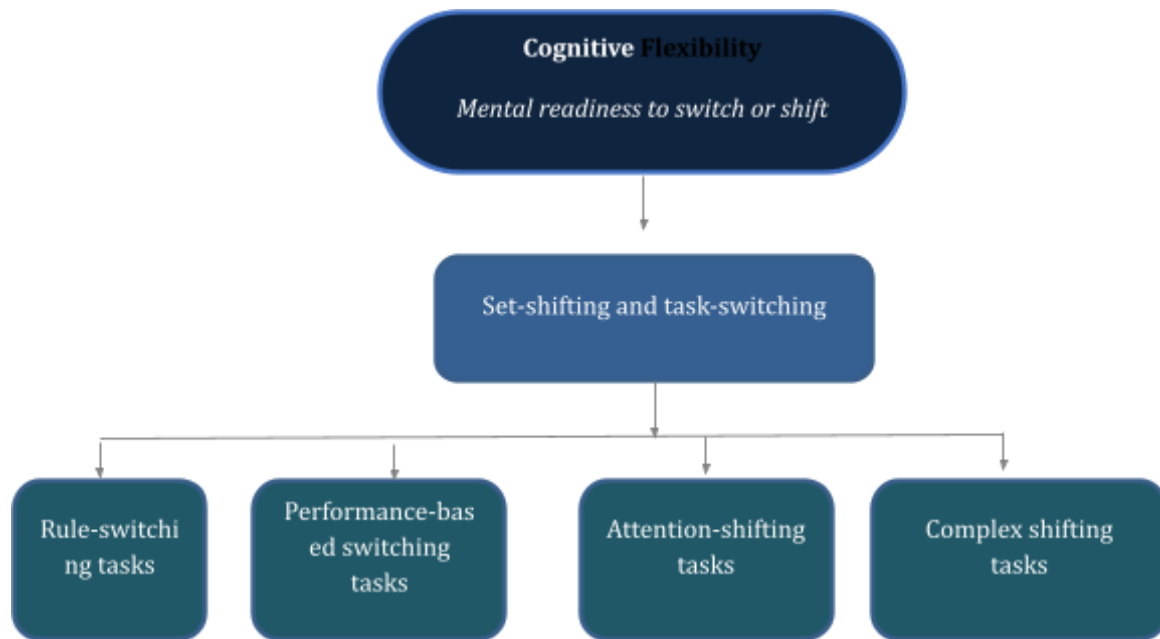


Figure 4. The general schema Developmental neuroimaging of cognitive flexibility (Kupis & Uddin, 2023)

This ability is closely linked to problem-solving, creative thinking, and resilience, all of which are fundamental in professional environments characterised by uncertainty and complexity. Studies in cognitive neuroscience have demonstrated that individuals with more significant cognitive flexibility exhibit enhanced decision-making abilities, increased adaptability in problem-solving tasks, and improved learning efficiency, making them more adept at navigating dynamic work environments (Dajani & Uddin, 2015). As the global workforce increasingly values interdisciplinary expertise and agility, cognitive flexibility in students through targeted educational interventions has become imperative.

Empirical research supports the view that cognitive flexibility is a predictor of success in complex work environments. Employees with a high degree of cognitive flexibility are better equipped to integrate diverse sources of information, transition seamlessly between tasks, and adjust strategies in response to shifting workplace demands (Kupis & Uddin, 2023). Neuroimaging studies utilising functional magnetic resonance imaging (fMRI) have identified specific neural substrates involved in cognitive flexibility, particularly the inferior frontal gyrus and anterior cingulate cortex, both of which are implicated in adaptive reasoning and error monitoring (Dajani & Uddin, 2015). These findings suggest that cognitive flexibility in students not only enhances academic performance but also builds neural resilience, preparing individuals for professional roles that require continual adaptation and innovation.

One of the most promising methods for enhancing cognitive flexibility in students is the implementation of Agentic Artificial Intelligence (AI) systems in education. Agentic AI, designed to provide adaptive and hyper-personalised learning experiences, has been shown to improve problem-solving skills by exposing students to dynamic, real-world challenges that require flexible thinking (Erarslan, Beliakova, & Kecherukova, 2021).

Through interactive learning environments, AI-driven systems encourage students to engage in critical thinking, collaborative problem-solving, and iterative learning processes, all of which contribute to the development of cognitive flexibility.

AI-driven adaptive learning systems offer a practical way to help students develop cognitive flexibility, preparing them for complex, interdisciplinary careers. As industries continue to evolve, enhancing cognitive flexibility will be essential for improving employability and long-term career success.

7. Conclusions

The intersection of neuroscience, artificial intelligence, and education is reshaping professional preparation for AI-centric sectors, as explored in the previous chapters.

Education and workforce preparation in STEM must integrate AI-based personalised learning, cognitive neuroscience insights, and industry-aligned skill development. Governments, businesses, and educators must collaborate to create lifelong learning ecosystems where AI systems can enhance rather than replace human potential.

Agentic AI and SWARMS (Specialised Working Agents in Responsive Multi-Agent Systems) unite multiple intelligent systems to tackle tasks such as risk assessment, progress tracking, and process improvement. This collaborative approach aligns well with STEM fields, where teamwork and problem-solving are crucial. It enhances AI's capability to address complex challenges within STEM disciplines.

Advanced Agentic AI systems will incorporate sophisticated adaptive learning capabilities, providing customized and context-sensitive support. These platforms embody the principles of Personalized Learning, featuring adaptive feedback, individualized pacing, and real-time insights. This approach, exemplified by tools such as GitHub Copilot, enhances the learning experience by dynamically adjusting to each user's needs and progress.

Agentic AI systems are emerging and integrating with other technologies, such as augmented reality (AR) and virtual reality (VR). This integration creates immersive and interactive learning environments, providing students with hands-on experiences in STEM subjects.

Agentic AI, as seen in tools like GitHub Copilot and Carnegie Learning's MATHia, is already making significant changes to STEM education. These technologies enhance learning outcomes, reduce cognitive load, and foster collaboration among students. It is essential to prepare students for new roles in an AI-driven workforce, where these tools help connect education with industry and ensure that learners acquire the necessary skills. Western governments and education systems must incorporate ethical considerations into AI policies, promote AI literacy, and guarantee fair access to AI-driven learning tools to support a more inclusive and responsible technological future.

Student competency building for the future workforce requires offering them industry-aligned tools: practical skills and knowledge. Advanced educational software offering personalised learning experiences and real-time feedback can significantly enhance student outcomes and promote inclusive, student-centered environments. As AI-driven systems are being integrated into educational technologies, universal accessibility is a must. The real-world examples presented underscore the potential of these tools to revolutionise STEM education and better prepare students for future challenges and opportunities.

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