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FLUENCY WITHOUT LEARNING: HOW AI-INDUCED COGNITIVE EASE DISRUPTS THE MECHANISMS OF DURABLE EDUCATION

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Abstract:
Artificial Intelligence is transforming how students learn by providing instant explanations, personalised guidance, and rapid feedback. These features create the impression of accelerated understanding and often lead learners to believe they are mastering material more quickly than before. Yet research on learning suggests that this impression may be misleading. Durable knowledge is built through productive struggle and desirable difficulties, which require effort, confusion, and active cognitive work. When AI removes these conditions, learning becomes easier in the moment but shallower in the long term. This paper examines how AI shortcuts the processes that support deep learning, how fluent output generates a powerful sense of cognitive ease, and how that ease produces an illusion of mastery in which confidence grows faster than competence. The analysis shows that AI can improve performance while quietly undermining the mechanisms that create lasting understanding.

Introduction

Artificial Intelligence is rapidly becoming a central tool in education, praised for its efficiency, responsiveness, and ability to deliver personalised instruction at scale. Students now have instant access to explanations, examples, feedback, and solutions, resources that appear to remove friction from the learning process and accelerate understanding. Yet this promise rests on an assumption that has rarely been examined: that making learning easier necessarily makes learning better.

Decades of cognitive science suggest the opposite. Durable learning depends on difficulty, on the uncertainty, confusion, and effort that force learners to retrieve, discriminate, reorganise, and make sense of new ideas. When the struggle is removed, the mechanisms that produce long-term retention and conceptual understanding are weakened. This raises a critical question: if AI reshapes learning around fluency and ease, what happens to the cognitive processes that depend on effort?

This paper argues that AI fundamentally alters the structure of learning in three ways. First, it removes the conditions of productive struggle and desirable difficulties that are essential for durable knowledge. Second, it replaces effortful cognitive work with fluent, polished answers that create a powerful sense of cognitive ease. Third, this ease produces an illusion of mastery: confidence rises, competence stagnates, and learners come to believe they understand material they have not actually learned.

By examining these mechanisms together, the paper shows that AI's greatest educational strength, its ability to make learning feel smooth, fast, and intuitive, is also the source of its greatest risk. What feels like learning may not be learning at all.

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1 Productive Struggle is essential for real learning

1.1 What is Productive Struggle and Desirable Difficulty?

We seek knowledge to uncover information previously unknown to us, and real learning begins in uncertainty rather than clarity. Before concepts feel intuitive, they first appear confusing, incomplete, and resistant to immediate understanding. Educational psychologists describe this period of learning as *productive struggle*—the phase in which learners deal with unfamiliar ideas, confront errors, and gradually reorganise their thinking into a coherent mental model. More formally, productive struggle is defined as "the process of engaging with challenging tasks or problems that require effort, critical thinking, and persistence to solve" (Young et al., 2023). This process involves (i) experiencing a level of cognitive discomfort, (ii) while actively working toward a solution.

Desirable Difficulties, as can be deduced from the name, are specific learning or practice conditions that are initially challenging for the learner but ultimately enhance long-term retention and transfer of knowledge and skills (A more in-depth analysis of this will be done later in the paper) (Bjork & Kroll, 2015) These difficulties are considered *desirable* because overcoming them activates the cognitive mechanisms essential for learning, understanding, and long-term retention.

The concepts of productive struggle and desirable difficulties are closely aligned instructional theories that recognise the importance of cognitive effort in enhancing learning. However, they differ primarily in their scope and focus, with one concentrating on the *conditions* of learning and the other on the *process* of the learner's engagement.

Both Productive Struggle (PS) and Desirable Difficulties (DD) share the fundamental goal of moving instruction beyond short-term memorisation to support robust, long-term learning.

Feature	Description
Focus on Long-Term Learning	Both frameworks prioritise durable retention and the transfer of knowledge and skills, even when this comes at the cost of short-term performance gains. In each case, sustained effort or "productive struggle" is treated as the mechanism through which deeper understanding is formed. Within the desirable difficulties framework, such effortful conditions are understood as those that optimise long-term retention and facilitate transfer across contexts. (Bjork & Kroll, 2015; McGowan, 2025; Young et al., 2023)

Reliance on Effort and Challenge	Both concepts centre on the deliberate inclusion of tasks that demand substantial mental effort, critical analysis, and sustained persistence. Productive struggle refers to the learner's active engagement with such demanding problems, whereas desirable difficulties describe the conditions that prompt this reflective, effortful processing. (Bjork & Kroll, 2015; Bjork & Bjork, 2020; Young et al., 2023; McGowan, 2025)
Optimal Difficulty is Key	For either mechanism to function effectively, the difficulty must be calibrated so that it pushes the learner without exceeding their cognitive capacity. Productive struggle occurs only when the challenge remains within the learner's zone of reasonable competence; once the task surpasses their prior knowledge or skills, the struggle ceases to be productive and the difficulty becomes undesirable. In short, the task must be *solvable in principle*, even if it requires substantial effort. (Bjork & Bjork, 2020; Young et al., 2023; Zeybek, 2016; Bjork & Kroll, 2015)
Cognitive Activation	A difficulty is beneficial only insofar as it activates the cognitive processes that underpin comprehension and long-term retention. Productive struggle, in this sense, requires learners to engage deeply with the structure and relationships among ideas rather than merely pursuing correct answers. (Bjork & Kroll, 2015; Young et al., 2023)

The core distinction between the two operates at different levels of analysis: *desirable difficulties* refer to the instructional conditions intentionally designed to introduce challenge, whereas *productive struggle* captures the learner's internal cognitive and affective engagement with those conditions. In other words, desirable difficulties are the pedagogical inputs, while productive struggle reflects the learner's processing of, and response to, them.

1.2 Why does effort lead to better understanding?

Effort enhances learning because engaging with challenging tasks activates the cognitive processes that drive long-term retention and conceptual understanding, not merely short-term performance. This mechanism sits at the centre of both productive struggle and desirable difficulties: when learning demands sustained, effortful thinking, it produces deeper processing and more durable knowledge. (Bjork & Kroll, 2015; Young et al., 2023; McGowan, 2025)

1.2.1 Enhanced Memory Storage and Retrieval:
Effortful learning strengthens the mechanisms underlying long-term memory by increasing *storage strength* rather than merely boosting short-term *retrieval strength*. (Bjork & Bjork, 2020) Difficulties are considered “desirable” because overcoming them activates the cognitive processes (such as controlled retrieval, elaboration, and discrimination) that support durable learning. (Bjork & Kroll, 2015; Bjork & Bjork, 2020). This dynamic explains the paradox widely noted in learning research: conditions that make performance appear to improve rapidly rarely produce lasting retention, whereas conditions that create difficulties and slow performance often enhance long-term memory and transfer. (Bjork & Kroll, 2015)

Retrieval practice exemplifies this principle. The act of retrieving information, especially under spaced or varied conditions that make retrieval effortful, functions as a potent learning event; retrieval success strengthens future accessibility more effectively than additional exposure through restudy. (Bjork & Kroll, 2015)

Within the New Theory of Disuse, this is explained by the inverse relationship between retrieval strength and storage strength: when retrieval strength is already high, restudying or recalling the material yields only small gains because the memory trace is already strong and requires little cognitive work. By contrast, when retrieval strength is low, and the learner must exert substantial effort to recall the information, the act of retrieval produces a much larger increase in storage strength. In other words, the more effort required to retrieve knowledge (without failing entirely), the greater the long-term learning that results. (Bjork & Bjork, 2020)

1.2.2 Promotion of Deep Processing and Conceptual Elaboration:
Effortful engagement pushes learners beyond surface-level memorisation and toward the underlying structures of the material. In productive struggle, this takes the form of sustained effort to interpret relationships among ideas and to make sense of concepts that do not yield immediate answers. (Young et al., 2023)

From a cognitive perspective, difficult encoding conditions extend processing time and promote greater conceptual elaboration, requiring learners to actively organise, differentiate, and connect ideas. This deeper level of processing (rather than mere repetition) supports the development of robust, meaningful, and transferable knowledge. (Bjork & Kroll, 2015; Young et al., 2023; Zeybek, 2016)

1.2.3 Benefits of Errors and Self-Correction:
Errors made during effortful attempts can enhance learning when the learner has the background knowledge needed to interpret corrective feedback. (Bjork & Kroll, 2015) Generating an incorrect prediction activates relevant knowledge, sharpens expectations, and prepares the cognitive system to encode the correct answer more effectively, a pattern observed in studies where error generation led to superior later recall. (Bjork & Kroll, 2015)

This "errorful generation" also focuses attention that passive study does not, increasing receptivity to feedback and strengthening the resulting memory trace.

Empirical work on second-language learning illustrates this effect clearly. When learners translate from their dominant L1 into a weaker L2, the task typically induces more errors because it requires generating unfamiliar vocabulary and grammatical structures rather than simply recognising them. This increased difficulty forces learners to make predictions, confront gaps in their knowledge, and engage in more intensive self-correction when feedback is provided. As a result, the processing devoted to resolving these errors produces substantially greater long-term retention than the easier reverse direction (translating from L2 to L1), which often allows learners to rely on recognition and yields fewer opportunities for meaningful cognitive effort (Bjork & Kroll, 2015)

1.2.4 Development of Metacognition and Resilience:

Effortful learning supports the development of metacognitive regulation by forcing learners to monitor their understanding, evaluate the effectiveness of their strategies, and adjust their approach when progress slows down. Productive struggle inherently requires this self-evaluation: learners must decide whether to persist, revise a method, seek alternative representations, or reframe the problem. These metacognitive operations strengthen learners' capacity to manage complex tasks independently. (Young et al., 2023)

Sustained engagement with challenging work also contributes to psychological resilience. Persisting through ambiguity, frustration, or partial failure builds tolerance for difficulty and cultivates a sense of agency when the eventual solution is reached. The experience of overcoming a demanding task reinforces the expectation that effort can lead to progress, which in turn supports motivation and future persistence. (Young et al., 2023)

Ultimately, effort enhances understanding because the cognitive system strengthens information that requires substantial processing to retrieve or encode. When a learner must work to recall a memory or make sense of a concept, that difficulty signals that the information is not yet stable, prompting deeper encoding and increased storage strength. As a result, knowledge that was initially hard to access becomes more durable and more readily retrievable in the future.

1.3 How confusion and uncertainty builds durable knowledge

Confusion and uncertainty are not incidental to learning; they function as catalysts for constructing durable knowledge. When learning feels easy, it often produces only superficial performance gains. (Zeybek, 2016) In contrast, confronting difficult or ambiguous material requires greater cognitive effort, which in turn strengthens memory and deepens comprehension. (Bjork & Kroll, 2015)

Confusion and uncertainty contribute to durable learning through several interconnected cognitive and affective mechanisms:

1.3.1 Activating Deep Cognitive Processing (The Effort Principle):
When learners encounter confusion or uncertainty, they must exert cognitive effort to interpret the material, test their interpretations and reconcile gaps in understanding. (Zeybek, 2016)

As long as the task remains within their reasonable capabilities, this effort creates *desirable difficulty*. The reason is straightforward: resolving confusion activates processes such as focused attention, discrimination among competing ideas, and construction of more precise mental representations.

Effort also deepens encoding. Challenging material requires learners to spend more time analysing relationships, generating explanations, and integrating new information with prior knowledge. This elaborative processing produces stronger and more meaningful memory traces than simple repetition. (Bjork & Kroll, 2015; Young et al., 2023; Roediger & Butler, 2011)

Retrieval follows the same principle. When recalling information is difficult (because the memory is not yet stable), the act of retrieval forces the cognitive system to reconstruct the knowledge. This reconstruction significantly increases *storage strength*, making the information more durable in the long term. In contrast, when retrieval feels easy, very little additional learning occurs because the system performs the task without meaningful cognitive engagement. (Roediger & Butler, 2011)

1.3.2 Leveraging Errors and Impasse:
Uncertainty often leads learners to make incorrect predictions or to reach a cognitive impasse, but these moments are not signs of failure: they are essential drivers of deeper learning. When a learner attempts to solve a problem under uncertain conditions, the errors they generate activate relevant prior knowledge and clarify the boundaries of what they do and do not understand. Empirical studies consistently show that this kind of errorful generation can *enhance* subsequent learning of the correct answer, because the learner has already engaged in active hypothesis formation. (Bjork & Kroll, 2015)

Errors also sharpen attention. Struggling to produce an answer heightens the learner's sensitivity to feedback, making the corrective information more salient and more deeply encoded than it would be during passive study. This attentional shift is a major reason why feedback following an incorrect attempt produces stronger retention than simply reading the correct information. (Bjork & Kroll, 2015)

Reaching a cognitive impasse functions similarly. When learners hit a point where existing strategies no longer work, they must reorganise or refine their understanding to proceed. Research shows that without such impasses (i.e, without moments where learners are forced to pause, reevaluate, and restructure their approach) deep learning is rare. These moments of difficulty compel the learner to engage in the conceptual reprocessing that leads to genuine understanding rather than superficial performance. (Zeybek, 2016)

1.3.3 Fostering Metacognition and Self-Correction

The discomfort that accompanies confusion pushes learners into active self-monitoring, transforming difficulty into productive struggle. When the path forward is not obvious, learners must pause and evaluate whether their current strategies are effective, what assumptions they are relying on, and where their understanding breaks down. This metacognitive regulation (planning how to proceed, monitoring progress, and revising strategies) is a core predictor of long-term learning outcomes and generally does not arise when tasks are too simple or immediately solvable. (Young et al., 2023)

Confusion also plays a critical corrective role by exposing gaps in understanding that learners often overlook. The Illusion of Explanatory Depth (IOED) demonstrates that individuals routinely believe they understand complex ideas more deeply than they actually do. When confusion forces them to articulate their reasoning in detail, their explanations often unravel, revealing vagueness or inconsistency. This confrontation with the limits of one's knowledge generates a more accurate self-assessment and often initiates conceptual refinement. In other words, confusion does not merely disrupt learning; it reveals what must be learned and directs cognitive resources to those weak points. (Chromik et al., 2021)

In addition, repeated engagement with manageable confusion builds resilience. Persisting through frustration teaches learners that difficulty is not evidence of failure but an inherent component of mastery. The resolution of confusion, when understanding finally "clicks", produces a distinctive sense of accomplishment that reinforces the value of sustained effort. Over time, these experiences cultivate a tolerance for intellectual struggle and a willingness to re-engage with challenging material, both of which are essential traits for deep, independent learning. (Young et al., 2023)

2 AI reduces productive struggle by offering instant, fluent answers

2.1 How AI shortcuts the process

Artificial Intelligence (AI) shortcuts the learning process by streamlining tasks that traditionally require sustained cognitive effort. Through rapid information retrieval, personalised guidance, and immediate feedback, AI minimises the time learners spend grappling with uncertainty and reduces the cognitive friction that normally promotes deep processing.

The literature identifies several mechanisms by which AI systems accelerate learning in ways that bypass the effortful processes normally required for deep understanding:

2.1.1 Acceleration through Personalisation and Pacing

AI-driven instructional systems shortcut the learning process by redesigning the sequence, pacing, and delivery of material so that learners encounter fewer obstacles, fewer bottlenecks, and fewer moments of uncertainty than they would in traditional environments. Instead of progressing through a shared curriculum with built-in slowdowns (such as waiting for teacher instruction, whole-class explanations, or natural periods of confusion), AI systems algorithmically compress the pathway to mastery. They do this by continuously predicting what the learner is ready for and pre-emptively smoothing the route ahead. The result is a learning experience in which the student spends minimal time struggling to interpret tasks, search for information, or resolve conceptual ambiguities.

AI systems infer a learner's proficiency from fine-grained performance data and assemble learning paths that keep the learner in a zone where progress is consistently achievable. In traditional instruction, learners often move through entire units regardless of readiness, re-encountering material that is too easy, too hard, or ill-timed. AI eliminates this inefficiency by filtering out redundancy and steering learners directly toward content the system predicts they can grasp with minimal confusion. This bypasses the exploratory, effort-driven phases of learning where students would normally test hypotheses, confront errors, and wrestle with partially formed ideas. (Harry, 2023; Xu, 2024)

Because AI models continuously evaluate micro-patterns in a learner's performance, they detect misconceptions or hesitation before the learner fully experiences the cognitive friction necessary for working through the difficulty independently. The system then supplies a hint, a scaffold, a worked example, or a simplified explanation. These targeted supports prevent prolonged impasse, a state that is typically uncomfortable but pedagogically valuable because it triggers deep processing, strategy revision, and metacognitive monitoring. By resolving the difficulty early, AI preserves forward momentum but also removes much of the uncertainty and struggle that normally mediate robust learning. (Harry, 2023)

AI tools dramatically reduce the search and struggle associated with information gathering. Instead of sifting through textbooks or attempting multiple solution paths, learners can request explanations, examples, or clarifications and receive immediate, highly specific responses. This immediate availability of tailored support increases subjective satisfaction and expedites task completion. It also compresses time spent on exploration, error-driven reasoning, or prolonged retrieval attempts: activities that, while inefficient in the short term, are known to strengthen long-term retention. ("Enhancing Students' Confidence and Understanding", 2024; Xu, 2024)

2.1.2 Immediacy of Feedback and Support:

AI dramatically shortens the feedback cycle by collapsing the time between a learner's action, the evaluation of that action, and the delivery of corrective information. In traditional learning environments, this loop is slow: students submit work, wait for grading, and only later receive feedback that guides their next attempt. The delay forces them to rely on memory, self-assessment, and independent reasoning while they wait. AI eliminates these delays entirely, converting a multi-step reflective process into an immediate stimulus–response sequence.

AI tutoring systems, including large language models like ChatGPT, provide real-time guidance the moment a learner hesitates or encounters difficulty. Instead of persisting through confusion, generating hypotheses, or attempting multiple solution paths, students can request clarification and receive tailored explanations instantly. Intelligent Tutoring Systems (ITS) further automate this process by continuously monitoring responses and delivering just-in-time hints, scaffolds, or corrections. This immediacy ensures uninterrupted progress, but also replaces the slow, effort-driven reasoning that traditionally mediates conceptual understanding. ("Enhancing Students' Confidence and Understanding", 2024; Harry, 2023)

Machine-learning-based grading tools and automated feedback engines reduce or eliminate the reflective pause between producing work and learning from mistakes. Students no longer need to revisit prior reasoning, compare solutions, or wait to discover whether their understanding holds. Instead, AI flags errors immediately and often supplies the corrected method or answer. Although this accelerates improvement in the short term, it also suppresses the iterative cycle of prediction, error detection, and self-correction that normally fosters metacognition and durable learning. (Harry, 2023; Tyler et al., 1979; Xu, 2024)

2.2 Fluent Output Creates Cognitive Ease

Fluent AI responses create cognitive ease by presenting polished, coherent explanations that are effortless for learners to process. Because the information feels immediately clear, learners often interpret this fluency as evidence of their own understanding. However, this subjective ease frequently masks a discrepancy between perceived mastery and actual grasp of the material, giving rise to the *Illusion of Explanatory Depth*: the mistaken belief that one understands a concept more deeply than one truly does. (Bjork & Bjork, 2020; Chromik et al., 2021)

Here is how the fluency of AI-generated responses produces cognitive ease through identifiable cognitive mechanisms:

2.2.1 Decision Fluency

AI-generated responses contribute to cognitive ease because they present information rapidly, coherently, and without visible effort. The smoothness and immediacy of these outputs reduce cognitive friction and create the subjective sense that processing the information requires little mental work. (Sanchez & Dunning, 2020)

Fluent output is processed more quickly and with fewer disruptions than traditional forms of learning. When explanations or solutions appear instantly, the act of receiving information feels effortless, and the learning experience becomes unusually fluid. This rapid, uninterrupted flow contributes directly to the sensation that the material is clear and easy to grasp. (Sanchez & Dunning, 2020)

AI tools eliminate the delays, hesitations, and micro-struggles typically involved in problem-solving. By providing instant clarifications, examples, or next steps, they remove the ambiguity and temporary confusion that normally require deeper cognitive engagement. The absence of these small difficulties creates a subjective ease that makes the task feel straightforward. ("Enhancing Students' Confidence and Understanding", 2024; Dempere et al., 2023)

Because AI systems offer concise and polished explanations, learners expend less effort parsing text, searching for resources, or reconciling competing interpretations. This reduction in mental workload produces a smooth processing experience in which the information "goes down easy," reinforcing the general feeling that learning is happening with little strain.

2.2.2 Reduction of Cognitive Effort and Friction

AI systems also generate cognitive ease by lowering the amount of mental effort required to engage with learning tasks. Much of what learners experience as "fluency" comes not merely from the speed of AI output, but from the way AI minimises the cognitive work traditionally involved in searching for information, interpreting ambiguous material, and resolving uncertainty. When explanations, examples, and clarifications are provided instantly and in a polished, coherent form, the learner experiences a smooth processing flow that feels effortless. (Harry, 2023)

AI tools eliminate the delays, hesitations, and micro-struggles that typically accompany problem-solving. By supplying immediate clarifications or next steps, they remove the temporary confusion that would normally require deeper cognitive engagement. Without these small moments of difficulty, the task feels more straightforward than it would through independent reasoning.

2.3 How cognitive ease and the illusion of understanding shift learning from active engagement to passive consumption

The cognitive ease and illusion of understanding produced by fluent AI output shift the learning experience away from active engagement and toward passive consumption. Because the material feels clear and effortless to process, learners expend less cognitive effort, engage in fewer critical evaluations, and encounter fewer opportunities for productive struggle. This pattern stands in direct opposition to established principles of effective learning, such as constructivism, productive struggle, and desirable difficulties, which emphasise that durable knowledge emerges from effortful, active cognitive work rather than passive reception.

This movement toward passive consumption can be traced to several specific changes in how learners process and interact with information:

2.3.1 Reduction of Active Cognitive Effort

Effort involves the allocation of limited-capacity central processing to an information-processing task. Research consistently shows that higher effort leads to stronger recall and retention than low-effort processing, and that effortful retrieval produces greater long-term learning than restudy alone. By generating fluent, rapid, and accurate responses, AI systems substantially reduce the amount of cognitive effort the learner must invest, replacing effortful processing with immediate clarity. (Roediger & Butler, 2011; Tyler et al., 1979; Faculty of Computing and Information Technology, King Abdulaziz University, 2024)

Conditions that yield quick performance gains (such as instant assistance and seamless explanations) typically do not support durable learning. Effective learning requires desirable difficulties: challenges that slow immediate performance but strengthen long-term retention and transfer. By providing targeted, real-time feedback and smoothing over points of uncertainty, AI tools reduce the learner's exposure to productive struggle, limiting opportunities for the effortful reasoning and persistence needed to deepen understanding. (Bjork & Kroll, 2015; Bjork & Bjork, 2020; Harry, 2023; "Enhancing Students' Confidence and Understanding", 2024; Young et al., 2023)

2.3.2 Shift from Self-Construction to Passive Acceptance

Constructivist learning theory holds that learning is an active process in which learners use sensory input and mental operations to construct meaning for themselves; it is not the passive reception of knowledge that exists "out there." (Hein, 1991)

When learners depend on fluent AI output, the learning experience shifts toward a transmission-based model in which the system presents ready-made interpretations and the learner's role is reduced to accepting them. AI functions as an authoritative guide that pre-selects, organises, and explains information, thereby discouraging the learner from engaging in the mental actions(i.e., questioning, interpreting, and reorganising ideas) that constructivist theory views as essential for building personal meaning. (Hein, 1991)

Constructivist learning also requires metacognitive activity: monitoring one's understanding, recognising confusion, evaluating strategies, and adjusting approaches during difficult tasks. When AI provides immediate, fluent solutions, learners are relieved of the need to reflect on their own reasoning or identify gaps in their understanding. This bypasses opportunities for self-correction, processes that normally help learners refine their thinking, update their mental models, and take ownership of their learning. (Young et al., 2023; Hein, 1991; Chromik et al., 2021)

2.3.3 Illusion of Understanding Hampers Critical Engagement

The subjective feeling of ease (fluency) acts as a strong cue for confidence and perceived understanding, leading learners to believe their knowledge is deeper and more accurate than it truly is. When this illusion takes hold, the motivation to question, scrutinize, or investigate information diminishes, shifting the learning experience toward passive acceptance rather than active engagement.

Because AI responses are rapid and fluent, decisions made with their assistance feel easy and smooth. Learners overweight this subjective ease as a signal of accuracy, experiencing a rapid rise in confidence that is not matched by a corresponding increase in actual competence. This inflated sense of mastery fosters a preference for passive, didactic approaches, where information is simply received, despite evidence that such methods are ineffective for long-term retention. (Sanchez & Dunning, 2020; McGowan, 2025)

AI-generated output can include inaccuracies, bias, or unsupported claims. However, the fluency of the presentation discourages learners from applying the critical thinking and reflective judgment needed to evaluate the reliability of the information. If the content aligns with the learner's fluency-induced sense of clarity, it is often accepted without scrutiny. This passive acceptance undermines the development of essential competencies such as evaluating evidence, identifying errors, and independently verifying claims. (Dempere et al., 2023; "Enhancing Students' Confidence and Understanding", 2024)

Taken together, these effects mean that AI-generated ease shifts learners toward passive consumption: with the struggle removed and understanding seemingly assured, there is little reason to question, explore, or engage in the effortful processes that active learning requires.

3 AI Creates an Illusion of Mastery

3.1 How Ease Produces the Illusion of Understanding

Cognitive ease creates an illusion of understanding because the mind misinterprets the smooth, rapid processing of information as evidence of genuine mastery. When explanations feel effortless to follow, learners mistake the fluency of the input for the strength of their own knowledge. This misjudgment is driven by two well-supported cognitive mechanisms: the tendency to confuse processing fluency with actual explanatory depth, and the reliance on fast, heuristic judgments that bypass the effortful processing required for durable learning.

3.1.1 Cognitive Ease Produces Decision Fluency and Overconfidence

Cognitive ease leads to an illusion of understanding because the mind treats rapid, effortless processing, known as decision fluency, as evidence of accuracy and mastery. When information is processed smoothly, people infer that the underlying judgment or explanation is correct, even when their actual understanding is shallow or incomplete.

Research shows that individuals become more confident in their judgments when those judgments are reached quickly and with minimal effort. The subjective smoothness of processing functions as a cue for correctness.

Beginners often show a rapid rise in confidence after only a few attempts at a new task. This surge in confidence tracks with increases in decision speed but *not* with increases in accuracy. In other words, the brain overweights speed as a signal of competence, leading learners to believe they understand more than they actually do. (Sanchez & Dunning, 2020)

AI systems intensify this effect by delivering instant assistance, guidance, and feedback. The speed and coherence of AI-generated responses create a particularly strong sense of fluency, resulting in elevated self-confidence and the perception that learning is progressing smoothly. The reduction in friction and frustration further reinforces the feeling that understanding has been achieved—even when little deep processing has occurred. ("Enhancing Students' Confidence and Understanding", 2024; Harry, 2023)

3.1.2 The Illusion of Explanatory Depth (IOED)

Fluent AI explanations can induce the Illusion of Explanatory Depth (IOED), a well-documented cognitive bias in which individuals overestimate the completeness of their understanding. Because AI presents information in polished, coherent, and easily digestible form, learners may believe they grasp the underlying mechanisms of a concept when, in reality, they only possess a superficial sense of familiarity.

The IOED arises when learners mistake recognition or surface-level familiarity for genuine explanatory knowledge. This bias is especially strong for concepts that involve complex causal structures: people feel they understand them, but cannot explain how they work at anything beyond a vague or schematic level.

AI and XAI systems often provide seemingly simple, local explanations of inherently complex behaviour. These simplified outputs mask interactions, causal depth, and structural complexity, producing an "easiness effect" in which the learner feels the system, or concept, is more transparent than it actually is. The smoothness of the explanation becomes misinterpreted as clarity of understanding.

A core driver of IOED is Label/Mechanism Confusion: the tendency to believe that knowing labels, components, or isolated features equates to understanding the mechanisms that connect them. Fluent AI output reinforces this bias by presenting well-organised descriptions that feel complete, even when the learner has not grasped the underlying causal chains.

The Illusion of Explanatory Depth typically persists only as long as the learner is not required to demonstrate their understanding in an active, detailed way. Once they are asked to explain a concept step-by-step, apply it independently, or use it in a new situation, the apparent clarity they felt during fluent processing often collapses. What seemed simple when presented smoothly now proves difficult to reconstruct, revealing missing causal steps, vague reasoning, or incomplete mental models.

This breakdown occurs because the initial sense of understanding was based on *recognising* a coherent explanation, not on being able to generate one. When the learner is no longer supported by the fluent structure of the AI's output and must rely solely on their own knowledge, the discrepancy between perceived and actual understanding becomes clear. Their confidence drops precisely because the task forces them to confront the limits of their explanatory ability.

In essence, the illusion dissolves at the moment the learner must *produce* or *use* knowledge rather than merely receive it. Tasks that require articulation, independent reasoning, or sustained problem-solving expose whether understanding is deep or merely superficial, making the earlier fluency-induced sense of mastery difficult to maintain. (Chromik et al., 2021)

In summary, cognitive ease misleads learners because it exploits the disconnect between performance and learning. Conditions that make performance feel fast, fluent, and immediately successful do not engage the effortful cognitive processes that build long-term retention or conceptual mastery. (Bjork & Bjork, 2020) Instead, the brain relies on rapid, heuristic judgments, its "fast thinking", and uses the subjective smoothness of processing as a cue for understanding. This leads learners to equate the feeling of ease with genuine knowledge, even when the underlying learning is shallow.

3.2 Mistaking AI's Mastery for One's Own

Learners tend to confuse externally provided solutions, explanations, or high performance with their own understanding when the conditions of learning generate cognitive ease and allow them to bypass the effortful processing required for durable, long-term learning. Under these conditions, the learner experiences a sense of fluency that is misattributed to internal competence, leading to overconfidence or the Illusion of Explanatory Depth (IOED).

These conditions typically arise when:

3.2.1 High Processing Fluency and Speed

When information is delivered quickly and with little cognitive friction, learners often misinterpret this ease as evidence of their *own* mastery. The underlying mechanism is *misattribution of fluency*: the brain automatically treats smooth, rapid processing as a sign that the knowledge is internally owned rather than externally supplied.

As a result, the subjective ease of following a fluent explanation becomes a cue for perceived mastery. Increases in decision speed, especially when assisted by AI, inflate confidence even when there is no corresponding improvement in accuracy or conceptual grasp. (Sanchez & Dunning, 2020)

Learners are further misled when AI systems provide simple, coherent explanations. The clarity of the presentation creates an "easiness effect," prompting learners to believe they fully understand the concept when, in reality, the fluency reflects the explanation's polished structure rather than the learner's internal understanding. (Chromik et al., 2021)

3.2.2 Lack of Necessary Cognitive Effort

Learning conditions that minimise intellectual struggle can produce high short-term performance while simultaneously preventing the deeper encoding processes required for long-term retention. When tasks feel easy and progress appears rapid, learners often assume that meaningful learning has taken place, even though the cognitive mechanisms that support durable memory have not been engaged.

Learners, and even instructors, are prone to this misjudgment because conditions that maximise immediate, observable performance rarely align with the conditions that promote lasting learning. Adult learners, in particular, tend to prefer passive, didactic experiences because they feel efficient and reassuring, despite extensive evidence that such methods lead to poor long-term retention. The subjective smoothness of performance masks the absence of the effortful processing required to build robust knowledge. (Bjork & Kroll, 2015; McGowan, 2025; Bjork & Bjork, 2020)

A core reason for this disconnect lies in the relationship between retrieval strength and storage strength. Memory research shows that long-term learning increases most when retrieval is difficult and effortful. When information is recalled under easy conditions—high retrieval strength—the gain in storage strength is minimal. Immediate answers from external systems bypass this productive difficulty, removing the "effort from within" that strengthens long-term memory. As a result, learners may perform well in the moment but retain little over time. (Roediger & Butler, 2011)

3.2.3 Absence of Self-Correction and Testing

The illusion of mastery persists when learners are not required to engage in the kinds of activities that expose gaps in their knowledge. In the absence of tasks that compel articulation, justification, or application, superficial understanding is never challenged, and the learner continues to rely on the misleading sense of clarity produced by fluent AI output.

Learners typically break these illusions only when they must explicate their reasoning or apply their knowledge in an active, structured way. Processes such as deliberate self-explanation or generating detailed step-by-step accounts reveal inconsistencies and gaps that fluent explanations can conceal. Without opportunities for this kind of diagnostic reflection, learners often maintain vague or incomplete explanations without realising their inadequacy.

Similarly, the lack of testing or diagnostic feedback prevents learners from recognising discrepancies between their perceived understanding and actual performance. Confidence remains high until real assessment forces a comparison between prediction and outcome. When such evaluative checkpoints are absent, the temporary feeling of ease produced by AI stands in as a misleading proxy for genuine understanding. (Chromik et al., 2021)

3.3 Expansion of the Competence Gap

Learners' confidence can continue to rise even when their actual understanding or performance remains shallow, particularly when the learning conditions emphasise ease, fluency, and rapid progress rather than the effortful, uncertain, and cognitively demanding processes shown in Section 1 to be essential for durable learning. In other words, the same conditions that eliminate productive struggle also create the psychological environment in which learners mistake short-term fluency for genuine competence. This produces a dissociation between confidence and accuracy, a metacognitive failure that grows wider as learning becomes smoother and more externally supported

When judgments are formed quickly and with little cognitive friction, learners interpret this ease as a sign of correctness, even when that inference is unjustified. Confidence tends to track the *speed* of a decision, not the *quality* of the reasoning behind it. As beginners accelerate rapidly in decision speed, often within only a few trials, their confidence rises sharply, while their accuracy improves slowly and linearly. AI systems amplify this effect by providing rapid, coherent answers that make problem-solving feel smooth and secure, boosting subjective confidence despite limited internal understanding. (Sanchez & Dunning, 2020)

The confidence–competence gap is especially pronounced early in learning, when learners lack a stable basis for accurately assessing their own understanding. Beginners often start with appropriately low confidence, but quickly become overconfident as they gain familiarity with task procedures, even though their conceptual accuracy lags far behind. This creates diverging learning curves: confidence surges upward, while competence increases slowly. Without the corrective forces of productive struggle (error, confusion, impasse), this divergence goes unrecognised. (Sanchez & Dunning, 2020)

Confidence rises again when learners transition from effortful learning to rote execution. Once the learner stops revising their understanding and instead begins repeating familiar patterns, the task feels easier, more predictable, and more controllable. This shift reduces cognitive effort and diminishes attention to feedback, particularly after errors. Performance feels smooth, but the underlying knowledge remains fragile. In contrast, Section 1 showed that durable knowledge requires precisely the opposite: sustained effort, continuous revision, and engagement with uncertainty. (Sanchez & Dunning, 2020)

Finally, confidence outpaces competence when the learning environment removes the very challenges that would normally expose gaps in understanding. Fluent explanations and streamlined assistance create an Illusion of Explanatory Depth (IOED), in which learners believe they understand complex ideas because the presentation feels simple. This illusion persists until they are required to generate explanations or apply the knowledge independently. Moreover, environments designed to prevent frustration or to maintain smooth progress eliminate the productive struggle, the effortful, metacognitively demanding phase that Section 1 identified as essential for restructuring mental models and strengthening long-term retention. (Chromik et al., 2021; Young et al., 2023)

Together, these conditions create the opposite of productive struggle: instead of effort leading to deep encoding, ease leads to inflated confidence. Learners come to believe they have mastered what they have merely recognised, and the gap between perceived and actual understanding widens precisely because the mechanisms that would normally correct this miscalibration—difficulty, error, reflection, and self-explanation—have been removed.

4 Conclusion

This paper has argued that there is a fundamental tension between how humans learn best and how AI currently optimises the learning experience. Section 1 established that durable understanding depends on productive struggle and desirable difficulties: effortful retrieval, confusion, error, and metacognitive self-correction are the conditions under which storage strength increases and conceptual structures are reorganised. In other words, real learning is built in the uncomfortable space between not knowing and knowing.

Sections 2 and 3 showed how AI systematically compresses or removes that space. By accelerating pacing, automating feedback, and providing fluent explanations on demand, AI reduces cognitive friction and makes learning feel smooth and easy. This ease does not merely change the *feel* of learning; it alters its *mechanisms*. Learners are exposed to less uncertainty, do less generative work, and receive fewer opportunities for effortful retrieval or self-repair. At the same time, the resulting cognitive ease is misread as evidence of mastery: decision fluency and polished explanations produce overconfidence, the Illusion of Explanatory Depth, and a widening gap between confidence and competence. Learners come to believe they have mastered what they have mostly recognised.

The implication is not that AI must be rejected, but that it cannot be treated as a neutral accelerator of learning. If AI is to support genuine education rather than an illusion of mastery, it must be constrained and designed to preserve struggle: to withhold answers, to demand retrieval and explanation, and to support uncertainty rather than instantly dissolving it. Otherwise, we risk building systems that make learning feel better while quietly making it worse.

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