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DEVELOPMENT OF A FULLY FUNCTIONING ARTIFICIAL DESIGN TUTOR – A QUEST FOR REFRAMING INTELLIGENT TUTORING SYSTEMS

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ABSTRACT
This paper presents a scrutinising attempt to design an artificial design tutor (ADT) that can specifically support development task throughout the phases of product development. In the format of a conceptual paper, it is arguable important to consider how artificial intelligence can support task related aspects, and more complex process-oriented design processes, not as an immediate substitute but as a supplement. With the purpose to present the founding principles of an ADT, the full paper adds insights through a series of interviews with academics and professionals working in the field of AI. The ADT is designed based on generative AI protocols and follows the escalating trend of utilising more and more areas with AI tools to facilitate and improve existing processes. From Newsweek magazine alone, it has been stated that numerous fully functioning AI apps are released every week, exceeding a growth rate of 38% in 2023. The AI components in an ADT can contribute to improved decision-making processes, where machine learning algorithms may be used to improve the ADT's ability to recognise and capture user preferences, emerging design trends, and successful design strategies. Consequently, given the range of scope, we still have not faced any ADT, which probably is connected to the complexity of the process itself. This paper hopes to inspire the cross-disciplinary efforts that advance the community of designers, and design educators, involving computer scientists, IT specialists, AI consultants, systems developers, and beyond, to further explore potential and risks of AI-enabled design support.

Keywords: Artificial design tutor, generative AI, design process, intelligent tutoring systems, ITS, LLM

1 INTRODUCTION
The thought about having a computerised tutor supporting the design process is far from new. Actually, very similar reasoning to the evolvement of the modern generative language modelling, e.g., ChatGPT, Wolfe and McDonald presented 40 years ago, a programming guide for establishing a user-centred approach in the interaction process [1]. While society is today overwhelmed with advanced algorithms capable to both, predict, intercept, activate, analyse, and evaluate any given data set, the normality of human-to-human interaction is by far the only given way for reaching new insights. Considering the capacity of AI, the major interest of its capability is witnessing the same exponential interest as when internet became present to all, fundamentally altering our way of life from that point forward. Eroding practices, or replacing actions? Depending on how we frame our point of view, the way AI may change and impact our living is ultimately affecting how we anticipate and allow this to get into our daily life. For establishing new design, the quest for progression is always present. Recently, Open AI announced that their new focus is to develop AI Agents, this was followed almost immediately by Microsoft introducing an AI Agent Foundation Model, which is a substantial step toward what is referred to as Artificial General Intelligence, or simply AGI [2]. While the impact of foundation models in AI transcends the realms of efficiency and resource management, establishing new capabilities, earlier considered to be exclusively within the realm of human intelligence. Still, research presents scepticism to how the potential role of an artificial generative agent may be. In a recent study determining barriers for AI in product development [3], the value of an intelligent system is based on data collection, data conditioning, algorithms, and human-machine collaboration. This, paper tries to explore what an artificial design tutor is, and what role it may have for supporting design education. Design education is characterised by dealing with complex situations, that are marked by an abundance of elements or

variables. This necessitates the processing of vast amounts of information, to reassure proper, and accurate progression. AI provides a speed beyond what the cognitive capabilities of even the most intelligent human tutor, senior lecture, or professor would be able to process. In recent years, AI, with its superior quantitative, computational, and analytical capabilities, has outperformed humans in handling complex tasks. Research has proposed partnering with AI to materialise the synergistic relationship between AI and humans combining the processing speed of AI in collecting and analysing information with humans' superior intuitive judgement and insight, captured in AI analytics or bots [4]. Human presence and interaction, in form of tutors are frequently regarded as the benchmark for fostering learning gains, yet with the precision of AI and possibilities to even render human tutoring this is posing a highly concerning topic for debate. As such, what has escalated in interest, also for learning purposes are Intelligent Tutoring Systems (ITS), capable to deliver adaptive guidance and instruction, evaluate learners, provide a specialised format for how to improve learning, and cluster and categorise learners based on level of expertise [5]. One strong reason for why ITS is a good starting point for further exploration is that these systems target to facilitate the learning process. However, these systems have not yet been explored in more complex experimental courses [5], which focus on problem-solving and decision-making, two foundational pillars of design education. ITS are capable to use multiple agent based computerised conversational experts, personalised to match both language and individual preferences, embodied in animated avatars [6]. Several questions arise based on the arguments and practices hitherto, yet to what extent is generative AI and ITS capable of transforming the design process and the objects exposed to design actions. For example, which decisions can be automated, and which ones cannot? These questions address the impact of AI on the principles of design. If AI induces significant changes in design practice, does it challenge the fundamentals of design? Is user-centeredness, for instance, questioned in the age of AI, and is design practice informed by significantly different principles? AI has the potential to assist individuals in integrating information, analysing data, and utilising the resulting insights to enhance decision-making. This causes the interest to further investigate the challenges and complexities that arises as AI and tools enabling interactions is gaining increased impact. This paper examines relevant research and share perspectives on application possibilities from AI experts to determine what it takes to establish and realise a fully functioning ADT.

1.1 Impact by AI tools

Numerous AI tools are rapidly being commercialised and made available for consumers and industry practices. This paper, inspired by management concerns, explores how AI is poised to change the way design is practiced, influencing decision-making and unfolding processes. AI drastically removes limitations in both design and learning, leveraging the performance of machine learning algorithms to achieve unparalleled levels of people-centeredness [7]. Designed to help find answers and establish new insights from vast data sets, IBM Watson presents a cognitive, problem-solving supercomputer, capable of processing data with a logic and precision of a superhuman. AI tools like Watson presents how context-specific decisions can be mastered at an unrivalled speed, transforming the ways in which students, instructors and other actors can influence how learning is intercepted, spurring new educational services [8]. Several unknown variables come in to play as interaction and tutoring modes radically emphasise processing aspects such as timing and accuracy. However, individuals require different means for interpretation and learning, depending on their preferred learning style. This poses more efforts to be directed towards exploring the potential customised features that can be provided.

1.2 AI tutoring potential

In recent years, ITS have progressed and evolved rapidly [5], positioning AI tutors as operators that have garnered attention as virtual teachers offering personalised learning approaches. While AI tutors aim to enhance learning progression and review learning plans, they utilise their experiences to categorise the academic status of a specific learner and design suitable actions [9]. An artificial design tutor serves as a computer-based system designed to assist and support individuals in the field of design education, capable of offering personalised, adaptive, and technologically enhanced learning experiences. Serving as a tool for both students and educators, an AI tutor enables a range of ways for deepening the understanding of design principles. Improving teaching processes by reducing and eliminating repetitive tasks, allows for increased precision, and a balanced way for connecting and interacting. The idea to enhance cognition through collaborative visualisation and iterative prototyping steps has long existed in the forefront for engineering design practices [10]. Still, AI can provide and

utilise a new form of advanced personalised and collaborative learning, featuring a digital tutor prototype and opportunities for a new educational model that offers integral learning activities for students [11]. Specifically, in this context, AI is employed to empower an ITS to produce accurate solutions for specified problems, and enable effective negotiation tactics [12], and supporting design phases [13]. The ITS incorporates mechanisms that enable students to request explanations about the solution process, serving as a means to facilitate learning.

1.3 AI biggest challenge

While being objective in format of a machine, that despite the risk of coloured "biased" coding, the advantage of being a mere object is also its immediate disadvantage. Reading peoples intentions, could yes probably be solved with sophisticated techniques eye-tracking, sensory systems and so on, yet the maturity level of how adoption and practice of this technology is still very uncertain, especially in the ethical concerns of how it may affect students being supported by a machine rather than a human. One alarming danger with AI tools in general, and with popular tools like ChatGPT in particular, is their propensity to be used for deceit, making misuse and abuse the important potential fear that argues for improvement of detection and transparency to end-users [14]. While AI may infuse more doubts and information conflicts, humans' perception is far more than what we currently grasp about coding, the sensations are simply difficult to replicate. But is this really a concern for content learning? If being factual, which teaching and learning so desperately try to focus on, precision is not something negative. It is precision with a nuance, or fake precision, meaning that the submitter unconsciously, and in very detailed ways, have been trying to humbly direct its extraction of data to what could potentially be right. However, as even a simple LLM example from ChatGPT may address, Figure 1 provides a snapshot that ridicules a system attempting to provide support, while lacking adequate fundamentals to do so properly. Essentially, it performs proudly, yet with the insecurity of a baby providing diapers.

Figure 1. Beyond a training data challenge for ChatGPT 3.5

1.4 What motivates an artificial design tutor?

As AI increases its capabilities in refining and updating its capacity, already now, there are far more advanced systems, capable to mirror sophisticated in-depth and realistic conversations with humans. AI is a self-learning system exploring and mastering bigger and bigger challenges. Suggesting that we are

moving towards a dynamic and adaptive design capability to handle varying levels of complexity. Learning and progressing in ways that were once destined for persistent humans is now intercepted in the age of generative AI, seen as nothing else than a suitable match, framed as:

"You never fail until you stop trying."

- Albert Einstein

What is conceptually showing a fitting description to the perceived elements of the ADT is captured by the ITS. Both ADT and ITS build upon computerised learning environments that integrate computational models from domains such as cognitive sciences, educational sciences, computational linguistics, and generative AI. The relationship between ITS and cognitive learning theories plays a crucial role in their design in the explanation functionality and the results impacting students' learning and perception [9]. Extensive mapping by past research provides indications of the stage-by-stage distribution of how AI could critically benefit designers' actions [13], by supporting design tasks and further examining process steps that require extensive use of various methods and processing capabilities. Several perspectives in how AI can support the design process also looks at the natural supporting function it provides. With further exploration of AI design, scrutinising expansion efforts that evaluates the designer's role provides a link towards deepening AI and human interaction [15]. However, rather than focusing solely on AI-integrated interaction patterns to emphasise the importance of an ADT, there is a shift towards a more grounded, human-centred perspective. This perspective prioritises validation and reliability checks by tracking, monitoring, and enhancing human efficiencies.

2 RESEARCH DESIGN

This explorative study, exposing theoretical paths not directly connected to design education, but given the immediate potential and together with the empirical investigation is made in alignment with to optimise clarity, consistency, and ease of reading. Web of Science was used with the search string 'artificial design tutor'. Notably, ITS showed high thematical relevance when no paper explicitly mentioned the term, 'artificial design tutor'. Furthermore, a mere handful of articles targeted any of the phases of the design process [13], [16]. These exemplified, discussed and provided perspectives on application design content relevance could be moderated and improved. Semi-structured interviews with three respondents were carried out. Respondent all had more than 20+ years expertise in the area of AI, currently operating in the Sweden with "Expert 1" being an independent IT consultant and "Expert 2", a R&D manager in a MNE dealing with process procurement, product development, and manufacturing support. The responses from these respondents, referred to as AI expert interviews within the paper, are presented in the findings as expert insights. One additional professional expert was interviewed, yet the coverage of this interview was not deemed eligible to provide enriching answers to properly relate to an ADT. Following the guidance by design science research methodology, the use of open-ended questioning is deemed particularly suitable for exploring new domains [17]. This contributed to understanding the in-depth influences and aspects related to an ADT, still the interviews provided neither narratives nor insights that could clarify distinct practices. To enhance transparency and establish conceptual beliefs on systematic grounds, an analytic process was used to extract key narratives related to the design process. Adopting a structured approach for transcript processing aims to improve the credibility for interpretations, enabling a more purpose-oriented screening process.

3 FINDINGS

AI were presented to have a galvanising overall support. There are despite the general enthusiasm also a few concerns that were raised related to algorithm bias, due to training limitation, and the difficulty to comprehend the design environment and inherent complexities. This may cause unpredictably due to personalised practices by individuals, especially for the uncertain outcomes when dealing with complex design tasks. One key concern was more to get programs and courses willing to test and integrate the potential of an ADT, because without systematically looking at pedagogical and practical concerns, simply ignoring it, will not benefit anyone. Experts shared the belief that an ADT should not be used as a substitute, blindfolding the human creativity, but rather as a mean for broadening the critical thinking

and to develop the design practice. To organise the influences and aspects of AI as captured by the narratives from the two experts, Table 1 presents a summary of the interviews.

Table 1. Summary of experts' beliefs about potential influences by an ADT

DESIGN PHASE	INFLUENCE/ASPECT	EXPERT 1	EXPERT 2
Research and Discovery	Generative AI and LLM Use	Access to tools for information search, extraction, and presentation.	ADT can support learners by identifying key concepts, trends, and gaps.
	Systematic Practice in Learning	Underutilised for learning despite immense opportunities.	Supports in early phase idea generation, iteration conceptualisation and need analysis.
Concept Development	Text-Based and Text-Image Analysis.	Enables perspectives, compiles research domains, connects image and text in different forms of presentation.	Generates ideas for projects and exploration.
	Creative Suggestions and Challenges	Generates creative solutions and alternatives, challenging existing ideas and beliefs.	Enhances idea generation and exploration.
Design and Prototyping	Data Analysis and Improvement	Breaks apart existing data points to improve the fitting and existing processes.	Functions as a mediating cost-efficient step for institutions and companies.
Evaluation and testing	Practical Applications and Pilots	More emphasis on validation and process refinement to address conflicting suggestions.	Demonstrates potential in pilot programs, fostering creativity, critical thinking, and practical skills.
Implementation and Production	Support for Teachers	Can enrich and support depth and authenticity of design projects.	Facilitates evaluation without being an immediate substitute for human tutors.
Feedback and Iteration	Validation and Process Refinement	Targets to improve refining processes, triggers feedback iterations, and output validation.	Supports continuous improvement and iteration based on data-driven feedback and insights.

The experts highlight the in-built knowledge capacity that supports the iterative use of an ADT and the proper utilisation of its potential. Additionally, they explain how an artificial design tutor could improve design by providing personalised feedback, identifying critical aspects, patterns, trends, and needs. By offering data-driven insights an ADT can potentially enhance learning outcomes, imposing a mediating and new format for optimising the design process.

4 DISCUSSIONS

This paper makes no claim that AI is new in any ways to the design community. However, the rapidly improved availability of AI tools, for end-users with no prior expert skills in programming, makes access and availability very interesting adoption consideration. To perceive cost-efficient value benefits of ADT and how such as a phenomenon can promote design processes, current concerns for adoptions goes beyond the potential, and sometimes get stuck at existing constraints, which may limit the ADT potential. Although generative AI shows compelling results, they also show vulnerability and obvious flaws [14]. From LLM like ChatGPT, and other similar tools as Google Gemini, Bing AI, and OpenAI Playground they comprise a convincing, yet somewhat a dubious power mean. While new AI-enabled tools are continuously being improved in precision and processing capacity [6], [9], they keep flourishing communication through improved interaction capabilities. This allows for improved user engagement while queries and operations are processed at more complex cognitive levels. Meanwhile, users, are strive for adopting tools that smoothen the interactive prompting. To enhance the practical benefits of an ADT, users need explore value benefits at different phases and increase validation and refinement strategies. Similar to recent research [13], an important design awareness is not about "if" a certain tool should be applied, but "what" tool should be applied, and "when". The conceptual idea behind the ADT is to emulate the chosen AI application, resulting in various user-oriented, interactive, and attentive tutoring agents. Similarly to how ITS can create personalised challenges and quizzes for students [5], [6], [8], an ADT may generate practical questions, that need deep level explanations and educational content tailored to individual needs. While early examples have shown so-called "hallucinations," where services have created an incorrect response due to limitations in the LLM model, an ADT is expected to value the input received throughout the interaction, and thus deemed critical to make a self-review assessing and critically evaluate the information provided.

5 CONCLUSIONS

This paper is set out to challenge existing forms, and think outside the box, introducing a crossbreed element of the ADT, combining LLM, with ITS and even given the technology format a simulated robotic presence. When trying answer questions on how an ADT could be designed and on the desired

criteria for how to utilise this format, literature offers a wide range of methods and approaches overlapping with ITS, generative AI and LLM. Ultimately, the paper is a framed conceptual reasoning attempt that has concentrated on what experts experienced and literature revealed. Indications provided state that an ADT is not at all far away, as complexity capacity increases so does generative AI solutions. Reframing ITS, this attempt hopes to direct further attention towards the design process and opening up a new path for inspiration within the community of Design Society and E&PDE. Potentially even a new research trajectory for design research and design education where ADT attempts can merge an obvious need for cross-disciplinary overlaps enabling future design education initiatives.

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