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AI-DRIVEN INSIGHTS IN AEC: LITERATURE DISCOVERY AND PRACTICAL APPLICATIONS

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Abstract

Artificial Intelligence (AI) is transforming the Architecture, Engineering, and Construction (AEC) industry. This paper summarizes an elective course where student teams explored AI's potential through comparing traditional and AI-assisted literature reviews. Starting with broad AI topics, students refined their focus to specific AEC applications, evaluated tools and models, and presented findings. They compared traditional and AI-driven literature review methods, highlighting strengths and limitations. The course demonstrated AI's growing impact on literature and practice in AEC. Students gained deeper insights into AI technologies and emphasized the need for ongoing learning to keep pace with rapid developments in the field.

Introduction

AI-based tools transform both the way we do literature reviews and the way we plan, build, and operate our build environment. This paper describes an elective course that openly explores both topics.

AI-based literature review tools promise significant time savings compared to traditional literature research processes. More and more AI-based tools to support the literature review process are emerging and it is difficult for students and professors to stay up-to-date. First studies show that a combination of traditional and AI-based literature tools seems to produce the best outcome. (Tomczyk et al., 2024).

AI-based use cases in the AEC industry are emerging rapidly. Artificial Intelligence (AI) has emerged as a transformative force in the AEC industry, offering innovative solutions that enhance efficiency, accuracy, and decision-making processes. The integration of AI in AEC spans various applications, including architectural design, project management, safety monitoring, and building operations. Recent studies have highlighted the significant impact of AI on improving project workflows and addressing industry challenges such as safety and productivity (Emaminejad et al., 2022). Most studies either focus on a specific AEC topic or a specific AI topic. Maureira et al. (Maureira et al., 2021) focus on the optimization of design and material properties of construction materials, as well as in the whole life cycle of buildings through Building Information Modeling (BIM). Other studies focus on Generative AI in the construction industry (Onatayo et al., 2024). Whereas broader studies of the AEC AI field only use traditional literature review methods (Darko et al., 2020).

This paper presents insights from an elective course, "Advanced Exploration of AI Use Cases in AEC," where students engaged in a structured exploration of AI's potential in AEC. By first using a traditional literature review approach, the students subsequently investigated their review and topic exploration with AI-based literature review tools. This allowed students to directly experience the differences between traditional and AI-based literature review methods, while also allowing them to explore specific areas of interest within the AEC domain in greater depth (see Figure 1). The process involved analyzing AI-based tools, models, and methods, and evaluating their practical applications in real-world scenarios.

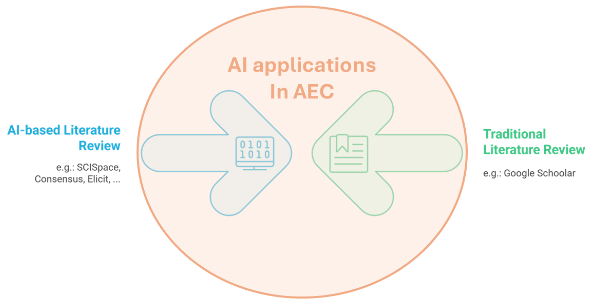

Figure 1: Using traditional and AI-based literature review approaches to investigate spefici AI topics in AEC

This paper describes our teaching concept in the elective course including the theoretical input, consultation, and the student presentations. First, we provide an overview of theoretical input, introduce the selected general AI topics, and highlight the AI-based literature review tools. Each tagged AI topic by student teams is summarized by describing the focused AI use case, illustrating the AI model categories considered, and the students' takeaway messages. We show the results of our student evaluations, discuss the outcome and processing of the course, and close with a conclusion and potential future improvements.

Teaching concept

This elective course is offered across four academic programs within the Faculty of Architecture and Civil Engi-

neering, welcoming both bachelor's and master's students. Given this faculty-wide approach, student interests in topics vary significantly. Additionally, prior knowledge of AI and experience in conducting literature reviews differ among participants.
To address these varying learning levels, the course was structured around targeted thematic inputs, group-based consultations, and student presentations to track progress and encourage discussion. The course was divided into four phases:

1. traditional literature review on the chosen broad topic
2. extended literature review incorporating AI-based tools
3. focused exploration of a specific use case
4. in-depth investigation of a selected AI tool or use case

Preceding those four phases was an AI introduction and a topic selection for each student team. Figure 2 provides an overview of this course structure.

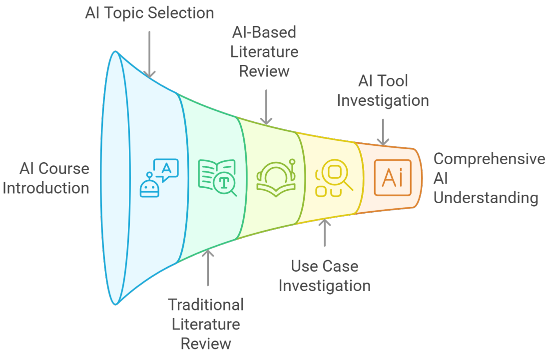

Figure 2: Course overview

Input for the students

The course began with a lecture providing an introduction to AI, both in general and specifically in the context of AEC. This included fundamental concepts such as the relationship between digitalization, structured and unstructured data, as well as an overview of generic AI models and principles.
As illustrated in Figure 3, AEC industry processes often rely on manual workflows that operate on unstructured data to produce an output. The next step towards automation involves structuring the data, enabling rule-based approaches to replace manual tasks. For AI models, however, structured input and output data are essential for training. Once trained, the model can make predictions based on new structured input data in the inference phase. In practice, many AEC processes remain manual and heavily dependent on unstructured data. Before AI can be meaningfully applied, an initial digitalization or structuring step is often necessary—this first step typically involves automation without AI. While some AI methods can assist in structuring data, this simplified view highlights an important point: AI is not always the best solution for every problem or use case.

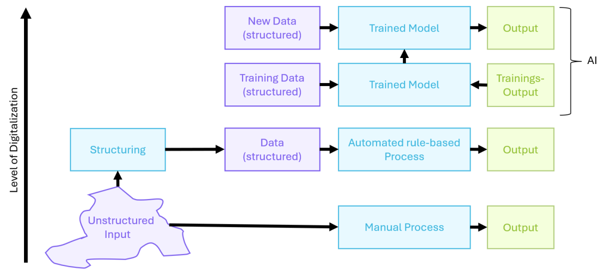

Figure 3: Digitalization, data and AI

Besides this generic AI topic introduction, in the first class the history, the challenges and dangers of AI, and categories of AI leading to machine learning were discussed. Based on Baduge et al. (Baduge et al., 2022) categorization of machine learning into supervised, unsupervised, and reinforcement learning, the different approaches are illustrated in class to establish the connection of neural networks as part of supervised learning. Finally, the professors illustrated examples of AI applications, spanning from Text-to-Image Generation (e.g., Midjourney (MidJourney, 2023), Leonardo AI (Leonardo AI, 2023), DALL-E (OpenAI, 2022a)), over energy forecasting based on regression methods, current ongoing student and research projects, leading into a detailed application example showing how deep learning can be used for automated identification of collapsed buildings (M. Bayraktar, A. Aldemir & B. Guldur Erkal, 2024).
Besides this first major input, the professors provided input to the two phases of the literature review: the traditional literature review with tools like Google Scholar and advanced literature review tools such as Perplexity (Perplexity AI, 2023), SCISpace (SCIspace, 2023), Elicit (Ought, 2023), Concensus (Consensus AI, 2023), ChatGPT(OpenAI, 2022b) and ResearchRabbit (ResearchRabbit, 2023) as shown and described in Table 1.

Student presentations

There were four presentations from each student team throughout the semester (see Figure 2).

1. Results from traditional literature review
2. Results from AI-based literature review and comparison of the literature review approaches
3. Results from a more focused use case investigation (looking at details of AI concepts and models)
4. Final presentation including an in-depth AI tool investigation

Student teams that participated in all student presentations did show significant progress in their understanding of AI in general but were also more specific in their focused topic.

Student consultations

Between the presentation dates, students were offered consultation sessions to discuss their progress with professors and receive guidance on their next steps. These ses-

Table 1: Summarization table of AI-based research tools

Tool	Description	Supports Scientific Papers	Data Source
Perplexity	AI-based search engine for retrieving concise answers to complex questions.	Partially	Web data, general knowledge bases, and cited sources.
SCISpace	Simplifies research papers with contextual insights.	Yes	Academic databases, uploaded papers.
Consensus	Aggregates research findings for yes/no questions.	Yes	Curated academic papers.
Elicit	Suggests papers for literature reviews.	Yes	Open-access academic databases.
ChatGPT	Conversational AI for brainstorming and summaries.	Partially	Diverse datasets (not academic-specific).
ResearchRabbit	Maps related research works visually.	Yes	Open-access papers and curated sources.

sions often included support in refining search keywords or crafting effective prompts for AI tools.
Throughout the course, it became evident that each student team followed a similar trajectory—starting with a broad topic and gradually narrowing their focus. Depending on the chosen topic, groups either leaned towards a research-oriented approach or a more AI tool-centric exploration. For research-focused topics, it was generally easier to find academic papers and detailed discussions on AI use cases and models. In contrast, for topics centered around AI tools, hands-on experimentation with the tools was more accessible, but finding relevant literature and gaining deeper insights into the underlying AI models proved more challenging. Understanding tool access limitations and the AI concepts behind them also posed additional difficulties.

The execution of the course

In the following subsections, the authors describe the actual execution of the course. The course was tough at the Technical University of Applied Sciences Augsburg during the winter semester 2024/2025 with 22 students spanning three programs: Architecture, Energy Efficiency Design, and Digital Master Builder. Following the structure outlined above in Figure 2.

Topics selection

The student teams selected the following topics for their exploration.

1. AI for Cost Estimation for construction
2. Integration of AI in Building Information Modeling (BIM)
3. Advantages of Using AI in Project Monitoring and Construction Management
4. AI in landscape architecture
5. AI enhanced 3D printing in Construction
6. AI Usage for energy optimization in smart buildings
7. AI in the Prefabrication of Wooden Components
8. AI in space organization and optimization
9. AI in Architectural Design
10. AI and Robotics in Construction
11. AI-Powered Tool to Simplify Data Collection for LCA (Life cycle assessment) and EPD (Environmental Product Declaration)
12. AI-Based Simulations Architecture (Fire protection)

The selected topics span a broad and interesting range of AI topics in the AEC industry. This broad selection of topics reduced the overlap in terms of topics to a minimum.

Phase 1: Traditional literature research

Early results from traditional literature research were limited due to the missing research experience of mainly bachelor students. Without specifically encouraging the use of ChatGPT, it was apparent that students naturally use it to support them in topic finding, exploration and source finding on the selected topic. Mostly, the relevant number of scientific literature was small and alternative sources such as online sources were shown at that phase. To support students in their traditional literature review, we selected a focused set of online resources, such as online tutorial videos.

Phase 2: AI-based literature research tools

In the second phase of the course, we encouraged the use of AI-based literature research tools shown in Table 1. Besides the four AI-based tools, we also encouraged the usage of ResearchRabbit to detect related research as well as to use ChatGPT in support of their literature research. While ChatGPT and Preplexity support scientific papers only partially, the other tools do properly support scientific papers. Furthermore, the table illustrates the different data sources of the six tools. For the presentation of this phase, we asked the students to perform a critical comparison of the two literature review approaches.

Phase 3: Use case investigation

Based on the research thus far, the focus in this third phase was on the use cases. To dig deeper into an AI topic a use case selection is useful to establish a meaningful context to look into which AI model categories are used, what data is used for input and output and what is the current status of implementation of the use case. Is it in the early research stage, are there any existing open-source research tools available or is the use case already commonly used and part of a startup or an established company?

Phase 4: AI tool investigation

Finally, the last phase was intended to focus on AI-based tools that already exist for the previously selected use case. In reality, this selection mostly happened in the previous phase and students used this last phase to get organized and prepare the final presentation.

Approach on course evaluation

As is customary in our courses, we conducted a course evaluation for this elective to collect structured feedback from students following their final presentations and prior to the release of grades. The evaluation was carried out using a standardized anonymous questionnaire, which included both quantitative Likert-scale items and open-ended questions. Core dimensions assessed included the overall quality of the course, relevance to professional practice, depth of understanding achieved, quality of instruction, pace of learning, clarity of assessment, and degree of student engagement during in-person sessions. Details on the evaluation from the students overall (see 6) and regarding depth of understanding (see 7) are presented in the results section.

In addition, the common questionnaire was extended to include specific items focused on students' experiences with the AI-based tools introduced during the course. The results of this AI-specific section are summarized in Table 2.

To complement the questionnaire, we also employed a qualitative approach by asking students to include in their second group presentations a reflection and comparison of traditional and AI-supported literature review methods. These reflective elements served as a form of structured anecdotal evidence, enriching the overall evaluation with students' personal insights into the use and applicability of the tools in the AEC domain.

Summary of students AI topics

This section contains a summary of the selected use cases of each AI topic.

1. AI Cost-Estimation for Construction

Automates and enhances the accuracy of cost estimation in construction projects by analyzing historical data and integrating with BIM for better resource allocation and budgeting.

2. Integration of AI in Building Information Modeling (BIM)

Optimizes construction schedules by forecasting delays, enabling efficient resource allocation based on project phases, and identifying potential budget overruns for risk management.

3. Advantages of Using AI in Project Monitoring and Construction Management

AI enhances safety management by using progress tracking and danger detection.

4. AI in Landscape Architecture

AI improves design efficiency, sustainability, and client satisfaction in landscape projects by analyzing spatial, environmental, and aesthetic factors.

5. AI-Enhanced 3D Printing in Construction

AI aids in automating construction processes by enhancing material deposition, optimizing designs, and ensuring structural stability in 3D-printed buildings.

6. AI Usage for Energy Optimization in Smart Buildings

AI-driven energy optimization minimizes waste, reduces costs, and improves sustainability by optimizing HVAC, lighting, and resource management in smart buildings.

7. AI in the Prefabrication of Wooden Components

AI optimizes construction scheduling and material ordering by creating detailed production schedules, calculating material order dates for just-in-time delivery, and improving resource usage.

8. AI in Space Organization and Optimization

Tools like Spacemaker AI assist architects and urban planners in optimizing site designs by analyzing factors like sunlight, noise, wind, and zoning regulations.

9. AI in Architectural Design

AI supports architects by assisting in conceptual design generation, sustainability analysis, and performance evaluation to improve efficiency and aesthetics.

10. AI and Robotics in Construction

AI-powered robotics enables autonomous material handling, inventory management, and precision in construction tasks.

11. AI-Powered Tool to Simplify Data Collection for LCA and EPD

AI automates the collection and processing of building product data for creating Environmental Product Declarations (EPD) and Life Cycle Assessment (LCA) reports.

12. AI-Based Simulations in Architecture (Fire Protection)

AI-based fire protection systems integrate emergency management solutions, including evacuation planning and

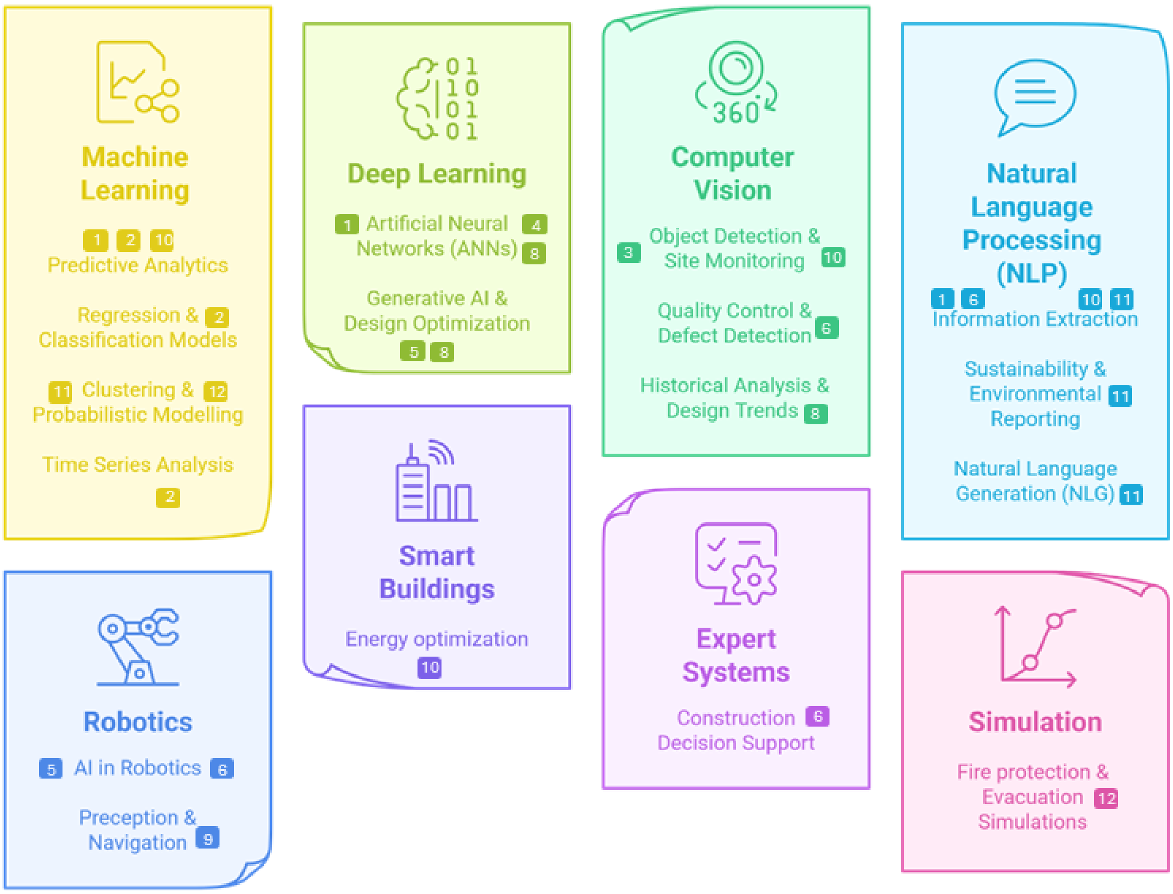

Figure 4: Relevant AI categories in AEC

hazard detection.

Figure 4 presents eight AI categories identified across the use cases. Each major technique encompasses more specific AI models and concepts applied within the cases. The use case numbers indicate which categories were utilized in each case. The breadth of topics covered in the course demonstrates the extensive range of AI applications explored.

In addition to analyzing AI categories, student teams were asked to formulate their own key takeaway messages based on their project work and reflections throughout the course. A summary of these student-generated insights is illustrated in Figure 5, highlighting themes ranging from the importance of substantial data preparation to the potential of generative design for broader architectural exploration. The seven major takeaways reflect the students' perspectives on AI's role in driving sustainability and innovation, improving accuracy and predictive capabilities, facilitating real-time adaptation and monitoring, unlocking new capabilities and emerging use cases, enhancing efficiency and automation, enabling better integration and decision-making, and addressing adoption challenges and considerations.

The course was designed to explore a broad range of AI applications within the Architecture, Engineering, and Construction (AEC) industry. One of the key lessons learned was the realization that the first AI-supported tools are available for architectural design. These tools show significant promise in aiding architects in their work. The student team specifically identified floor plan generation as a potential game-changer for their academic projects. Although the tools investigated thus far are not yet capable of producing floor plans in a manner that efficiently supports architects, the reliable generation of floor plans seems to be within reach.

Another noteworthy finding was the limited deployment of robots on construction sites. The few robots currently in use are highly specialized, performing specific tasks. In this context, the student team focused on robots designed to address logistical challenges within construction environments.

Additionally, the use of AI techniques to support the generation of Environmental Product Declarations (EPDs) was initially met with skepticism, given the reliance on available numerical data in EPDs and the reproducibility of results of EPDs. However, further investigation revealed promising methods for data extraction and even data verification. As a result, the project has been extended, and further exploration of AI applications in the context of EPD generation is ongoing outside of the elective course.

Finally, almost of AI topics except the well-sensored smart

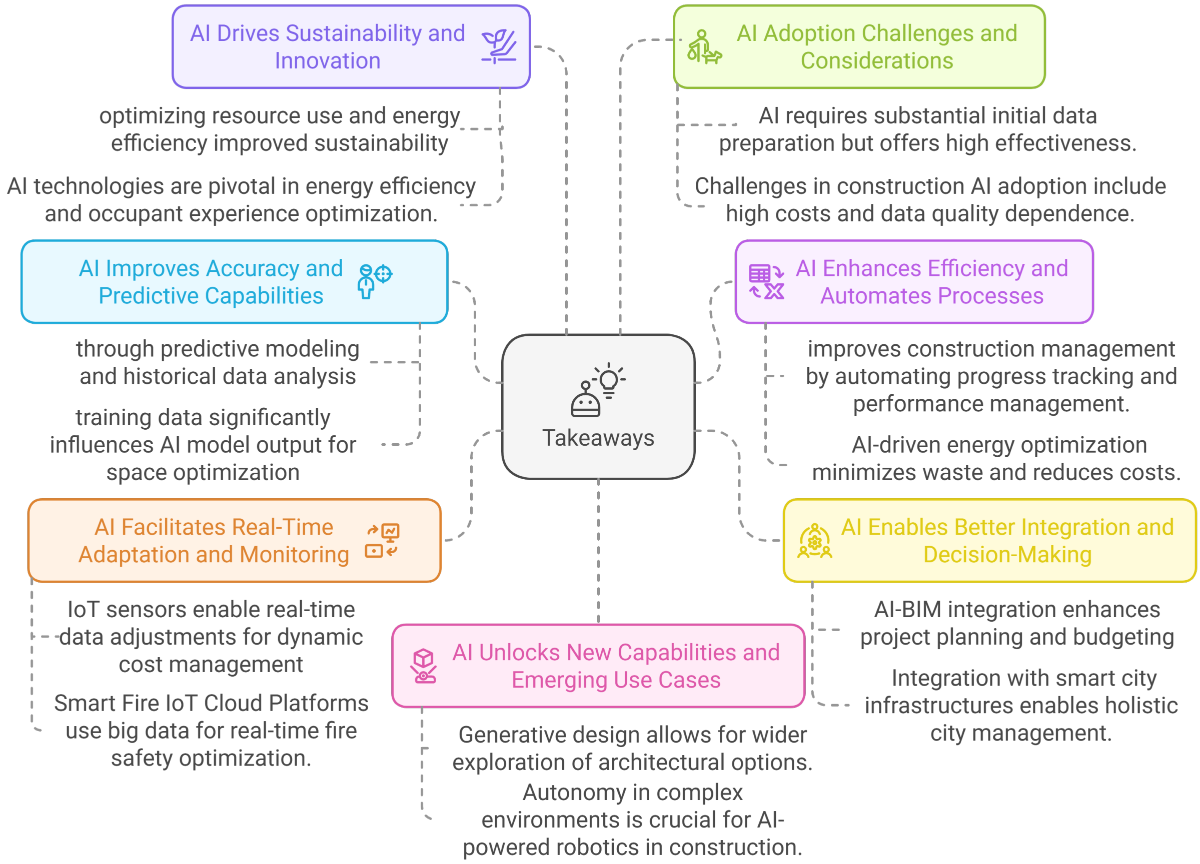

Figure 5: Key takeaways from student groups, collected during the final reflection session

building case study are facing the data scarcity issue. This observation confirms that the AEC industry is lagging behind on digitization and thus data availability, which could otherwise foster a fast-paced adaptation of AI technology.

Results and Discussion

AI technologies have significantly transformed various aspects of the construction industry, from cost estimation and project monitoring to architectural design and energy optimization. Key AI models, such as Predictive Analytics, Machine Learning, and Neural Networks, have been instrumental in enhancing accuracy, efficiency, and sustainability. Emerging tools have automated processes, reduced manual errors, and improved resource management. AI-powered robotics and IoT-integrated systems have further optimized construction workflows and safety management. The integration of AI with Building Information Modeling (BIM) is changing project planning and budgeting, enabling better resource allocation and dynamic cost management. Real-time data adjustments via IoT sensors and continuous learning from historical data are allowing AI models to adapt and provide more relevant insights over time. AI-driven energy optimization in smart buildings has the potential to minimize waste, reduce costs, and enhance occupant experiences. The use of AI in prefabrication and 3D printing may streamline production processes and ensure structural stability. AI-based fire protection systems could integrate emergency management solutions, enhancing safety through early fire detection and intelligent evacuation planning. The automation of data collection for Environmental Product Declarations (EPD) and Life Cycle Assessment (LCA) reports can improve efficiency and compliance with standards. However, the adoption of AI in construction faces challenges such as missing expertise, data quality dependence, and the need for substantial initial data preparation. Successful AI adoption requires overcoming these challenges and ensuring integration with existing workflows. Continuous collaboration with domain experts and ongoing improvement of AI models are essential for maximizing the benefits of AI in construction.

The concept of this elective course proved effective in terms of student participation and outcomes. Both the exploratory nature of AI-based literature review tools and the focus on AEC AI led to insightful final results. During the course, student teams evaluated various AI-driven literature review tools, followed by a formal evaluation after the course. The results of this evaluation are presented in Table 2. The table shows that students are most familiar with ChatGPT, using it most frequently and gen-

Table 2: AI-based tools and Categories

Category	ChatGPT	Research Rabbit	SCISpace	Consensus	Perplexity	Elicit
Usage	●●●●●	●●●●●	●●●●●	●●●●○	●●○○○	●●○○○
Intuative UI	●●●●●	●●○○○	●●○○○	●●○○○	●●○○○	○○○○○
Quality	●●●●○	●●●●●	●●●○○	●○○○○	○○○○○	○○○○○
Quantity	●●●●○	●●●●●	●●●○○	○○○○○	○○○○○	○○○○○
New aspects	●○○○○	●●●●●	●●●●●	●○○○○	○○○○○	○○○○○

erally favoring it over other tools. The tools that generated the most output—both in terms of quantity, quality, and novel insights—were rated the highest. While many students highly recommended Consensus, its actual usage varied, possibly due to individual preferences between outspoken and reflective students. The limited use of Perplexity and Elicit likely stems from time constraints; once students identified enough relevant papers, they tended to stop searching. While the authors experienced more efficient literature review results due to the combined literature review approaches, the quality of the outcome was not formally evaluated. This could be accessed in a future version of the course.

The overall outcome of the course on the AI topics and related research was quite satisfactory. Typically, a student team does have a diverged quality output, for elective courses, however, in this case the outcomes were better than expected. Students investigated specific AI categories and researched one technique or model in quite some detail. One group was even writing small code snippets to illustrate how a regression model is used. We also noticed that discussions about specific AI model topics did appear between student teams. The overall well-received feedback from the course evaluation can be seen in Figure 6. The students' assessment of their knowledge deepening, supported by the course, shows very positive results (see Figure 7). This indicates that the students confirmed the significant learning effect of the course.

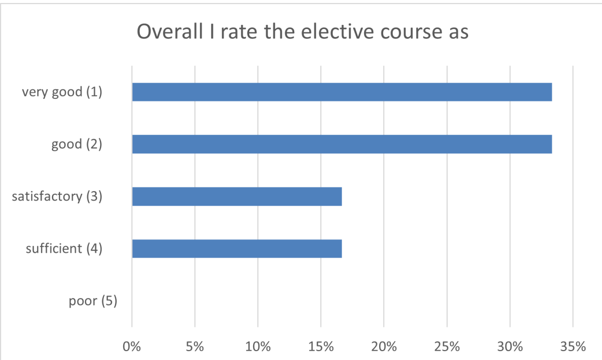

Figure 6: Overall assessment of the students in context of the course evaluation

Beyond the formal course evaluation, several learning outcomes were evident throughout the elective. The course

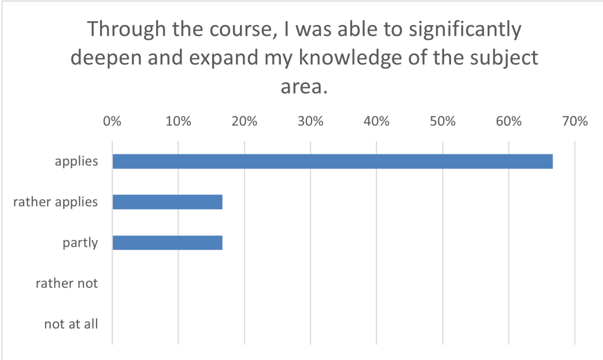

Figure 7: Assessment of the students on their knowledge deepening supported by the course

fostered future-oriented skills such as critically comparing AI-supported and traditional research methods, evaluating the applicability of AI tools in domain-specific AEC contexts, and independently exploring emerging digital technologies. For example, the application of AI in landscape design was entirely new to most students and even to the instructors, illustrating the exploratory and interdisciplinary nature of the course. Through the combination of a traditional literature review and an AI-based approach, students recognized that no single method is superior; rather, the strength lies in combining both to enhance the depth and efficiency of research. This hands-on comparison allowed students to internalize the value — something that is difficult to convey through lectures alone. The eight AI categories offered diverse entry points into AI in AEC. These categories enabled students to apply abstract concepts in practical ways, supported by targeted consultations that helped deepen their understanding of their chosen topic. Since students selected their own AI topics, the resulting outcomes varied but were notably richer due to this autonomy and individualized feedback, which fostered engagement, critical thinking, and self-directed learning.

Conclusion

This paper has explored the transformative impact of Artificial Intelligence (AI) on the Architecture, Engineering, and Construction (AEC) industry through the lens of an elective course, "Advanced Exploration of AI Use Cases in AEC." The course provided students with a comprehensive understanding of AI's potential by combining traditional literature research with AI-assisted tools, culminating in practical use case investigations.

The paper highlighted the course's teaching concept, which included structured phases of literature review and AI tool exploration. The paper detailed the specific AI topics selected by student teams, ranging from cost estimation and BIM integration to project monitoring, landscape architecture, and fire protection simulations. Each topic was explored through the lens of practical use cases, relevant AI model categories, and key takeaways. This approach not only provided students with hands-on experience but also underscored the practical applications and limitations of AI in the AEC domain.

The findings from the course demonstrate the significant benefits of AI in enhancing research efficiency, accuracy, and practical applications within the AEC industry. The rapid growth of AI publications and tools reflects the industry's increasing adoption of AI technologies. Students' evaluations and presentations revealed a deepened understanding of AI concepts, models, and their practical implications, highlighting the importance of continuous learning and adaptation in this fast-evolving field.

Future improvements to the course could include more hands-on experiences with AI-based tools, increased collaboration with industry professionals, and a focus on emerging AI trends. Future versions of this course could build on the research of the students on the twelve topics, allowing a deeper and updated look into each. This would allow a structured evaluation of the students' key takeaway messages in peer reviews. Overall, the course has successfully equipped students with the enhanced knowledge and skills to leverage AI in their future careers, contributing to the ongoing innovation and advancement of the AEC industry.

Acknowledgments

The authors would like to thank the students of the course "Exploring Advanced AI-based Tools in the AEC Industry" at the Technical University of Applied Sciences Augsburg for their valuable contributions. We also extend our gratitude to the software developers who supported this work by providing access to their tools through free trials, academic licenses, or individual free licenses.

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