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Between Acceptance and Scepticism: An Investigation into Secondary School Students' Attitudes toward Artificial Intelligence in Chemistry Education

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Abstract: Artificial Intelligence (AI) is increasingly integrated into daily life and various other sectors, including medicine, agriculture, and education. While AI offers personalized learning, automated feedback, and reduced teacher workload, its formal use in schools remains limited. Nonetheless, many students already engage with AI tools such as ChatGPT to understand concepts and access information, raising questions about their perceptions and competencies. This study investigates students' prior experience with AI in school as well as their AI literacy. Further, it examines changes after a teaching unit using AI tools and compares AI supported learning to traditional instruction. Results indicate that hands-on exposure enhances students' self-efficacy, cognitive engagement, and ethical awareness, though confidence in creating AI-driven solutions remains lower. Students valued both AI-supported and teacher-led learning, suggesting that students benefit most from hybrid approaches. Ethical considerations were prominent, emphasizing fairness and responsible use, yet technical understanding of AI design lagged behind. Overall, structured AI education can strengthen skills, ethical reflection, and problem-solving, but successful integration requires balancing technological tools with teacher guidance, supporting higher-order skills, and promoting sustained engagement.

Keywords: AI teaching · Chemistry lesson · Secondary school · Traditional teaching

Laura Naumann is currently pursuing her doctoral studies in chemistry education at Ludwig-Maximilians-Universität München, after completing her bachelor's and master's degrees in chemistry at the University of Heidelberg. Her research explores how artificial intelligence can be integrated into chemistry education to support inclusion and foster equitable learning opportunities. She is particularly interested in how digital tools can empower teachers to create accessible learning environments for diverse students. Her broader academic interests include teacher training, educational innovation, and inclusive science education.

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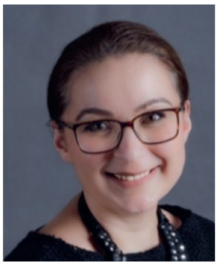

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1. Introduction

Whether through voice assistants, smart homes, or ChatGPT, Artificial Intelligence (AI) has become an integral part of everyday life. People interact with AI technologies daily, often without realizing it. Beyond private use, AI is transforming entire sectors such as medicine, agriculture, and education.[1] For example, AI systems already support surgeons in complex procedures and enable precision farming through robotics and sensor technologies. These applications illustrate how AI is reshaping work processes and highlights why younger generations also perceive it as relevant: almost half of surveyed students consider AI important for achieving their career goals.[2] Buxmann and Schmidt[3] even describe AI as the '*most important foundational technology of our time*'.

Education, too, is increasingly shaped by AI. Learning platforms can personalize instruction, provide automated feedback,

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and adapt to learners' needs.[4] Intelligent Tutoring Systems (ITS) offer individualized learning paths and real-time support, while teachers benefit from reduced administrative workload and more targeted interventions. Despite these opportunities, however, the use of AI in schools remains limited. A recent survey found that only 17% of students experience AI in their lessons under formal rules, while over a third reported that AI is hardly addressed at all.[2]

At the same time, many students already use AI tools such as ChatGPT to define concepts, better understand complex topics, or access information more quickly.[2] This raises important questions about how students perceive AI in the classroom. The present study therefore investigates their prior knowledge toward AI in school contexts, with a particular focus on changes in perception after a teaching unit using AI tools. In addition, it examines how students assess their own AI competence and how they compare AI-supported learning to traditional instruction. Given the growing significance of AI in society and the still limited role it plays in schools, such insights are crucial for understanding its potential in future learning environments.

2. Theoretical Background

Artificial Intelligence (AI) is gaining increasing significance in the education sector. Initially, AI was primarily taught within higher education institutions as part of computer science curricula.[5] At this stage, AI was understood as a discipline aimed at automating intelligent behavior.[6] The focus was on imparting theoretical foundations and developing algorithms to foster a deep understanding of AI systems and their underlying technical principles.[7] In this context, the emphasis was on 'learning about AI'.

Over time, however, the role of AI in education has evolved. Today, AI is not only relevant as a subject of computer science but also serves as a method and tool across various disciplines.[8] In this context, 'learning with AI' has gained increasing importance, where AI functions as a supportive tool for teaching and learning processes. This includes the potential use of AI for personalized learning, such as providing individualized feedback or adaptive learning content tailored to the specific needs and progress of students.[9] Consequently, AI is no longer solely taught as subject matter but increasingly perceived as a transformative technology shaping and advancing education.[5]

The growing accessibility of AI also allows younger learners to engage with the technology. AI-based approaches can provide interactive and playful learning experiences, fostering early competencies and a foundational understanding of AI.[5] With this, the concept of 'AI literacy' has gained prominence, referring to the ability to apply AI-related knowledge and skills.[10] AI literacy represents a subset of digital competence, specifically addressing the use and understanding of AI technologies. The European DigComp 2.2 framework serves as a reference for defining the dimensions of digital competence.[11]

In the DigComp 2.2 framework, digital competence is defined as the ability to use digital technologies safely and effectively in everyday life and lifelong learning contexts. Within this framework, AI literacy is divided into three key dimensions: knowledge, skills, and attitudes.[11] The knowledge dimension includes a fundamental understanding of AI functionality, applications, and relevant legal aspects. The skills dimension involves the practical ability to select and operate AI tools to optimize various aspects of life and solve problems. The attitudes dimension emphasizes understanding AI's opportunities and risks, enabling learners to engage critically in societal and political discussions.[11]

Ng *et al.*[5] further conceptualize AI literacy based on Bloom's cognitive domains to provide a deeper understanding of this competence. The first level encompasses understanding and remembering AI concepts, equipping learners with foundational knowledge, skills, and attitudes without requiring prior experience. Students are encouraged not only to use AI applications but also to comprehend the underlying technologies. The second level focuses on applying and analyzing AI, enabling learners to utilize AI in everyday contexts and develop practical competencies, including problem-solving and critical analysis. The highest level involves evaluating and creating AI solutions, promoting the ability to make informed decisions, critically assess AI technologies, and develop innovative applications.[5]

The DigComp framework and the Bloom-inspired model complement each other, offering a holistic approach to AI literacy development. While DigComp emphasizes practical competence and reflective attitudes, Bloom's taxonomy structures the progression of cognitive skills from basic understanding to complex evaluation and creation. Educational strategies can thus be aligned with learners' developmental stages: primary school students develop basic trust and understanding of AI, secondary students apply knowledge in collaborative problem-solving, and adult learners or university students utilize AI for academic and professional purposes.[5]

Student engagement with AI also depends on their willingness and intrinsic motivation. Studies indicate that AI literacy alone does not determine readiness to engage; self-confidence and perceived relevance are crucial factors.[10] Intrinsic motivation, arising from personal interest rather than external rewards, enhances learning outcomes and can be strengthened through AI-based learning tools that provide personalized feedback, gamification, and interactive materials.[12] Properly designed AI tools can foster autonomy, critical thinking, and personalized learning pathways, supporting individual development and academic achievement.[13]

ITS represent a significant application of AI in schools. ITS provide adaptive instructions by analyzing students' prior knowledge, cognitive needs, and emotional states, offering personalized guidance while supporting teachers in monitoring progress.[14] Empirical studies show that ITS particularly benefit lower-performing students by offering individualized support, highlighting AI's potential to enhance learning equity.[15]

Despite these opportunities, challenges remain. Generative AI may negatively affect learning if used to bypass engagement with core content, limiting critical thinking and problem-solving.[16] Therefore, AI should complement rather than replace traditional teaching methods, with careful teacher supervision and limited, targeted use in cooperative learning settings.[17]

Although the use of AI in education is increasingly discussed, there is still limited empirical research on students' perceptions of AI and the effects of AI-supported learning tools on motivation and learning behavior. Most studies focus on higher education,[9,11] while research on secondary education, particularly in chemistry classes, is scarce.

This study addresses this gap by examining students' attitudes, perceptions, and behavior, and by analyzing the impact of an AI-supported chemistry lesson.

Accordingly, the research questions are:

1. What role do students' prior experiences with AI play in their assessment of AI-supported learning?
2. How do students' attitudes and perceptions of AI in the classroom change after an AI-supported lesson?
3. How do students evaluate traditional instruction compared to AI-supported instruction in terms of support, understanding, and collaboration?

3. Methodology

3.1 *Context of the Study*

A lesson on alkanes in a German secondary school chemistry class was conducted, integrating AI-based research. The topic was chosen for its relevance to everyday life and connection to energy concepts, such as the use of methane and its environmental impact. Students explored alkanes' properties, structures, and the homologous series while developing critical thinking, collaboration, and communication skills. The lesson included discussions on positive and negative aspects of alkanes, research with AI tools, and hands-on activities. Key learning goals are aimed at understanding alkane properties, applying knowledge of chain length effects, and evaluating environmental impacts.

As part of this work, the platform '*Fobizz*' was used for the AI-supported lesson and it is widely used in schools in Bavaria.

3.2 *Research Method*

This study investigated the perceptions of students regarding AI in the classroom bases on a pre-post design.

The questionnaires are based on the instrument developed by Ng *et al*.[18] to assess AI literacy. A four-point Likert scale (strongly disagree to strongly agree) is used, without a neutral option, to encourage clear responses. The pre-questionnaire includes two open questions on prior experiences with AI and 22 Likert items in three categories: (i) affective learning (motivation, self-efficacy); (ii) cognitive learning (knowledge, application, evaluation, creation); and (iii) AI ethics. The post-questionnaire includes two open, reflection questions and 31 Likert items, covering: (i) affective learning; (ii) cognitive learning; (iii) behavioral engagement, and (iv) 'AI *vs.* traditional instruction', a self-developed scale comparing students' views on AI-supported and non-AI-supported teaching.

Data from both questionnaires were analyzed descriptively in Excel. Open responses were categorized following Mayring and Fenzl's[19] content analysis approach. For the post-test, reliability was additionally assessed using IBM SPSS Statistics Version 29 (SPSS = Statistical Package for Social Sciences), calculating means, variance, and Cronbach's alpha for internal consistency.

3.3 *Participants*

The study sample consisted of 46 students from a rural secondary school (Realschule) in Bavaria: 28 from a ninth-grade class and 18 from a tenth-grade class. Of these, 75% identified as female, 20% as male, and 5% as diverse.

The number of participants differed between the pre- and post-questionnaires, as the surveys were administered on different school days and not all students were present on both occasions. In total, 44 students completed the pre-questionnaire (26 ninth grade, 18 tenth grade), while 43 students completed the post-questionnaire (28 ninth grade, 15 tenth grade). Participants were between 14 and 16 years old.

The ninth-grade class was a tablet-based class, while the tenth-grade class was a non-digital class. According to the teacher, both groups were characterized by a heterogeneous performance level.

As the study was limited to only two classes from one secondary school in the same region, the generalizability of the findings may be restricted. However, the classes do not differ from other classes by any characteristics. Thus, some general tendencies in the interpretation can be given.

4. Results

4.1 *Results of the Pre-Test*

The pre-test questionnaire contained two open-ended questions allowing multiple responses. The first asked: '*In which subject or project have you already used or heard about AI? Please describe*'. The most frequent answer (14 of 56 mentions) referred to using AI for presentations, followed by nine references to having only heard about AI in class. Three students reported using AI for homework, while five indicated no connection to AI in school.

The second question focused on current usage patterns. Students most often reported translation tools (29 of 63 responses), followed by regular use of Siri (10 responses). Only three students stated they did not use any AI applications.

In the domain of knowledge and understanding, results showed that 87% considered themselves to have a solid basic knowledge of AI and 95% believed they could use AI applications. However, only 30% felt capable of comparing different AI concepts.

In the domain of AI ethics, students demonstrated clear awareness of responsible use. Most (84%) acknowledged risks of AI misuse, and 73% supported strict testing of AI systems. While 59% agreed that users should consider design and decision-making processes, opinions were more divided here. A large majority (86%) believed AI should benefit all people, regardless of gender or physical ability, and supported transparency regarding purpose, functioning, and limitations. Seventy percent assigned responsibility for AI use to humans, while 91% recognized AI's potential to support disadvantaged groups.

4.2 *Results of the Post-Test*

The post-test questionnaire served to evaluate the teaching unit. The most frequently mentioned positive aspect (17 of 43 responses) was working with AI, followed by group work (11 responses) and independent learning (7 responses). In response to '*What could be improved?*', nearly half (20 of 41) suggested no changes, while 11 students requested more time and five wanted additional support. Further results are presented in Table 1.

Table 1. Results from the post-test.

Category	Number of Items	Cronbach's α	Mean Score	Variance
Intrinsic Motivation	4	0.549	2.60	0.136
Self-Efficacy	4	0.839	2.99	0.024
Applying, Evaluating, Creating	3	0.487	2.67	0.491
Own Behavior	5	0.685	2.57	0.158
Collaboration	3	0.712	1.94	0.217
AI vs. Traditional	12	0.765	3.05	0.115

The findings suggest that students' intrinsic motivation and general behavior toward AI-supported learning are largely neutral, indicating neither a strongly positive, nor a strongly negative view. In contrast, self-efficacy was relatively high and consistent, suggesting that students feel confident in their ability to engage with AI-based learning processes. Collaboration received the lowest ratings, pointing to potential challenges or limited experience with cooperative learning. Variations in reliability across subcategories highlight that some measures were more stable than others and should be interpreted with caution.

Particularly relevant for the comparison between traditional and AI-supported learning was the category AI *vs.* traditional teaching. With a mean of 3.05, this lay in the upper scale range, suggesting strong agreement. Additionally, these categories were divided into the subcategories teaching with AI and traditional teaching (see Table 2).

Table 2. Teaching with AI *vs.* traditional teaching.

Category	Number of Items	Cronbach's α	Mean Score	Variance
Teaching with AI	7	0.789	2.94	0.128
Traditional Teaching	5	0.553	3.16	0.099

Students evaluated teaching with AI neutrally to slightly positively, with relatively consistent responses and good reliability. In comparison, traditional teaching was rated somewhat more favorably, with particularly uniform opinions, though the reliability of this measure was lower.

Behavioral engagement results indicated mixed tendencies: 81% planned to use AI in the future, but only 47% intended to keep up with new technologies, and fewer than 40% were eager to explore new AI functions. Collaboration on AI topics outside class remained rare.

Overall, both teaching methods were viewed positively, but traditional approaches received slightly stronger agreement.

Additionally, regarding AI *vs.* traditional teaching, students strongly valued teacher explanations (95%) and discussions (91%). At the same time, most (88%) acknowledged AI's usefulness for quick answers and 74% for supporting comprehension. However, 65% trusted teacher-provided information more than AI-generated content. Many preferred direct teacher interactions (88%) but appreciated AI for repetition (81%) and self-paced learning (86%).

4.4 *Comparison of Pre- and Post-Test*

The following presents the results of the individual components and items captured in both the pre- and post-questionnaires.

The teaching unit led to an increase in intrinsic motivation. Agreement with the everyday relevance of AI rose from 61% to 70%. In contrast, interest in learning about AI slightly decreased, with agreement dropping from 77% to 72%. The proportion of students who viewed learning about AI as enriching for daily life increased from 32% to 42%, while disagreement decreased from 68% to 51%. The results also highlighted students' sustained curiosity about new AI technologies; agreement remained high at around 60%, although it showed a slight decline.

Students' self-efficacy improved after the teaching unit. Confidence in successfully completing AI-related tasks increased significantly from 75% to 95%. Similarly, the assessment of their ability to manage projects in this area rose from 82% to 91%. The belief in successfully mastering AI knowledge and skills also increased, with agreement rising from 70% to 79%. Only in the evaluation of achieving good grades in AI-related assessments was there a slight shift toward uncertainty, with agreement decreasing from 82% to 79%.

The cognitive learning category, which includes applying, evaluating, and creating, reflected a changed perception among students. Agreement with using AI for problem-solving increased from 87% to 93%, with 5% of students providing no response in the pre-questionnaire. However, in self-assessment of developing AI-driven solutions, agreement decreased from 34% to 26%. At the same time, agreement with evaluating AI applications and concepts increased from 64% to 77%.

5. Discussion and Implication

The results of this study allows insights into the students' current level of prior experience and their perception of AI-based teaching and thereby has several implications for AI-supported learning and curriculum design. Overall, the teaching unit enhanced students' self-efficacy, ethical awareness, and cognitive engagement with AI, while highlighting areas for further development, particularly in motivation, and collaboration.

The increase in students' self-efficacy and ability to evaluate AI applications suggests that structured, hands-on exposure to AI can effectively build confidence and competence, even among learners with limited prior experience. These findings align with broader evidence from meta-analyses showing that active, technology-supported learning interventions improve students' perceived competence and problem-solving skills.[20,21] However, the lower confidence in creating AI-driven solutions indicates that higher-order skills require additional scaffolding, iterative practice, and teacher guidance.

Students demonstrated strong ethical awareness, emphasizing fairness, transparency, and responsible use. This finding resonates with prior studies suggesting that integrating ethics into STEM and AI education increases students' critical reflection on technology.[22] Yet, the divided opinions regarding understanding AI design highlight a persistent gap between ethical understanding and technical literacy, underscoring the need for curricula that combine ethical reasoning with hands-on technical tasks.

Students valued both traditional teacher-led instruction and AI-supported learning, suggesting that hybrid models may be most effective. The appreciation of AI for rapid information access, repetition, and self-paced learning supports findings from meta-analyses show that adaptive learning technologies and AI tutors can complement traditional teaching.[23,24] At the same time, students' preference for teacher explanations indicates that AI tools should remain supplementary rather than substitutive.

While most students planned to continue using AI, engagement with novel AI functions and collaborative learning remained limited. This pattern aligns with prior research emphasizing that motivation and social learning components are critical for sustainable technology adoption in educational settings.[25,26] Designing AI-based interventions that fosters exploration, peer interaction, and co-creation may increase long-term engagement. The study underscores that AI education can enhance cognitive, motivational, and ethical outcomes, but must be thoughtfully integrated into curricula. Future research should examine longitudinal effects, investigate interventions to support creative AI problem-solving, and explore collaborative learning strategies. Additionally, combining quantitative measures with performance-based assessments could provide a richer understanding of students' AI competencies.

Finally, the teaching unit gives a first indication that AI-supported learning has the potential to strengthen students' skills and ethical awareness, particularly when combined with traditional instruction. The findings highlight the importance of balancing technological tools with teacher guidance, supporting higher-order skills, and fostering collaborative and sustained engagement with AI. This contributes to a growing body of meta-analytic evidence supporting the efficacy of well-structured, technology-enhanced learning interventions in promoting both cognitive and motivational outcomes.

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