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The Implementation and Evaluation of Open Educational Resources for Teaching Artificial Intelligence and Ethics in Computer Science Education: A Design-Based Research Approach

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Zusammenfassung

Die Etablierung von Open Educational Resources (OER) ist von Interesse, da sie die Arbeitsbelastung von Lehrkräften erheblich reduzieren kann. Bislang wurde jedoch nur eine begrenzte Anzahl qualifizierter Unterrichtsmaterialien veröffentlicht, insbesondere in Fächern aus dem Bereich der Informatik (IT, Informatik, digitale Grundbildung).

Diese Studie untersucht, welche Hilfestellungen aktuelle Fachliteratur für die Erstellung von OER bietet. Darüber hinaus sollen Daten erhoben werden, die die Beurteilung von Schüler*innen zu bestimmten OER-Unterrichtssequenzen widerspiegeln. Zur Bewertung der Qualität der Materialien wird das Modell von Zawacki-Richter & Mayrberger für OER herangezogen.

Die in dieser Studie verwendeten OER bestehen aus strukturierten Unterrichtsplanungen, die von Lehramtsstudierenden im Rahmen eines Seminars zu Computerethik und 21st Century Skills mit dem Schwerpunkt Künstliche Intelligenz (KI) und Ethik entwickelt wurden. Diese Unterrichtseinheiten wurden von mir zunächst als Praktikantin (1. Zyklus) und später als externe Lehrkraft (2. Zyklus) in einer Sekundarstufe unterrichtet, während die Fachlehrkraft den Unterricht ohne Eingriff beobachtete, um eine objektive Erprobung zu gewährleisten. Als Mentor der Lehramtsanwärterin sowie als Seminarleitung für das Computerethik-Seminar war diese Person intensiv in die Qualitätssicherung der OER eingebunden.

Die der Studie zugrundeliegende Methodik ist designbasierte Forschung. Zur Evaluation der Materialien wurden Schülerfragebögen, Beobachtungsprotokolle und Feedbackrunden eingesetzt. Die Ergebnisse zeigen, dass kontinuierliche Überarbeitung und iteratives Testen entscheidend für die Entwicklung qualitativ hochwertiger OER sind. Die Schüler*innen schätzten den Alltagsbezug ethischer Fragestellungen zu KI, wiesen jedoch auf den Bedarf an verständlicheren Erklärungen und interaktiven Elementen hin.

Diese Studie verdeutlicht das Potenzial strukturierter OER im Informatikunterricht, betont jedoch zugleich die Notwendigkeit fortlaufender Anpassung auf Basis von Schülerfeedback. Die Erkenntnisse leisten einen Beitrag zur Verbesserung der OER-Entwicklung, indem sie deren Relevanz, Zugänglichkeit und Wirksamkeit bei der Förderung digitaler Kompetenzen und ethischer Reflexionsfähigkeit sichern.

Abstract

The establishment of open educational resources (OER) is of interest because it can significantly reduce the workload of teachers. To date, only a limited number of qualified teaching materials have been published, especially for subjects in the context of computer science (IT, informatics, digital technologies).

This study will examine what assistance recent literature provides for the creation of OER. Furthermore, it seeks to obtain data which reflects students' evaluation of specific OER teaching sequences. To ascertain the quality of the materials, they will be evaluated according to Zawacki-Richter & Mayrberger's framework for OER.

The OER used in this study are structured lesson plans developed by undergraduate students in a teacher training course on computer ethics and 21st-century skills, with a focus on artificial intelligence (AI) and ethics. These lessons were taught to secondary students by me as a trainee (1st cycle) and later as an external teacher (2nd cycle). The class teacher/mentor, who observed and gave feedback on the interventions happened to be the computer ethics course lecturer; hence, they were highly involved in the quality assurance of the OER.

The underlying methodology of this study is design-based research and used student questionnaires, observation notes, and feedback sessions to evaluate the materials. Results indicate that continuous refinement and iterative testing are essential for producing high-quality OER. Students appreciated real-world applications of AI ethics but highlighted the need for clearer explanations and interactive elements.

This study shows the potential of structured OER in computer science education while emphasizing the necessity of ongoing adaptation based on student feedback. The findings contribute to the improvement of OER development by ensuring their relevance, accessibility, and effectiveness in fostering digital literacy and ethical awareness.

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1. Introduction

The rapid evolution of computer science, particularly in artificial intelligence (AI), presents significant challenges for education, as its pace far exceeds that of many other disciplines (Schubert & Schwill, 2011). AI literacy has become essential in this context, encompassing not only technical proficiency but also an understanding of ethical concerns, data biases, user rights, and the implications of AI-driven decision-making (Adams et al., 2023; UNICEF, 2021). Given the ethical complexities introduced by AI, educators must develop both technological expertise and the ability to critically evaluate AI-based outcomes (Celik, 2023).

To address these challenges, Open Educational Resources (OER) have emerged as a promising solution for enhancing computer science education. OER are openly licensed teaching and learning materials that allow for adaptation and redistribution (UNESCO, 2019). By integrating OER into AI education, curricula can be enriched, diverse pedagogical approaches can be employed, and active engagement with AI ethics can be promoted (UNESCO, 2019).

Despite their potential, research on the effective implementation and evaluation of OER for AI and ethics education in computer science remains limited. This study attempts to address this gap by investigating how OER can be designed and utilized to support both AI literacy and ethical awareness.

The primary objective of this thesis was to explore quality assurance of OER in computer science education. More specifically, lesson plans, which were designed by undergraduate students in a computer ethics class, were tested for their effectiveness. By analyzing their impact on teaching and learning, this research contributes to the development of a more comprehensive and adaptable educational framework.

2. Research questions

The present study seeks to address the following research questions, utilizing appropriate data collection methods to ensure comprehensive and reliable insights.

1. What assistance does literature (from 2005-2025) provide for the creation of OERs?
    a. Literature review to be used for data collection.
2. How do students evaluate OER teaching sequences regarding features such as interest in the topic, perceived knowledge gain, and tool use?
    a. Student questionnaires to be used for data collection.
3. How well do the tested teaching concepts meet the quality criteria according to Zawacki-Richter & Mayrberger based on the teacher's experience?
    a. Teacher's observations, mentor feedback to be used for data collection.

3. Theory

3.1. Pedagogical Considerations

A key concept in shaping computer science education is *Didaktik der Informatik*. The presumed English translation "didactics in computer science" does not fully serve as an equivalent for the German terminology. According to Schubert & Schwill (2011, p. 7), it encompasses the study and design of teaching and learning processes related to computer science at all stages of life—from early childhood education to professional training and lifelong learning. In the context of teaching artificial intelligence and ethics, the connection between subject-specific knowledge and real-world experiences (Schubert & Schwill, 2011: 13) is crucial, as students must not only acquire technical proficiency but also develop a reflective understanding of ethical implications. *Didaktik der Informatik* investigates how knowledge, skills, and attitudes toward computer science are taught and acquired, making it an essential component of computer science teacher education.

Learning in computer science is not a passive process but rather an active engagement with concepts, practices, and mindsets. Harlow et al. (2018, p. 225) highlight that students bring prior knowledge, perspectives, and experiences to the classroom, which influences their perception of new content. Consequently, educators must design learning environments that foster individual cognitive growth and offer a supportive, adaptive context for exploration and inquiry. This approach moves beyond simple knowledge transfer and instead focuses on cultivating problem-solving abilities, critical thinking, and ethical reasoning.

However, traditional educational models, such as the Factory Model, often prioritize standardization over deeper comprehension. As McKeag (2023, p. 7) points out, the emphasis on standardized testing can lead to surface-level learning, where students focus on memorization rather than meaningful engagement with the subject matter. In the context of artificial intelligence and ethics education, such limitations underscore the need for pedagogical strategies that encourage analytical skills and the application of knowledge to complex, real-world challenges. By considering these factors, educators can create more effective and engaging learning experiences that prepare students not only for technical mastery but also for ethical and responsible participation in the digital world.

Relevance of computer science education

Computer science education has become an essential component of modern general education, comparable to foundational skills such as reading, writing, and arithmetic calculations (Bachinger et al., 2013, p. 68). In today's world, information and communication technologies are deeply embedded in all aspects of life, influencing personal interactions, professional environments, and societal structures. To navigate this digital landscape effectively, individuals must understand the underlying principles of these technologies, utilize their potential responsibly, and manage associated risks. Such competencies are crucial not only for economic success but also for active participation in public and private life (Bachinger et al., 2013, p. 68; Schubert & Schwill, 2011, p. 7).

The growing presence of digital systems in daily life highlights the need for critical awareness and responsible usage. Computers are not merely tools for efficiency; they are powerful instruments capable of reshaping social power dynamics and influencing fundamental rights. Their role in automating information flows affects decision-making processes, work environments, and leisure activities. This widespread influence underscores the importance of understanding both the potential benefits and the ethical implications of digital technologies (Schubert & Schwill, 2011, pp. 7, 26).

To engage meaningfully with these complex systems, individuals must develop a nuanced understanding of their functionalities and limitations. This awareness not only empowers users to leverage technology effectively but also fosters critical thinking about its impact on privacy, autonomy, and power relations. In this context, computer science education serves as a form of digital empowerment, enabling individuals to navigate digital systems confidently and ethically (Schubert & Schwill, 2011, p. 26; Hubwieser, 2007, p. 64).

Overall, the relevance of computer science education extends beyond technical proficiency. It plays a crucial role in preparing individuals for the complexities of digital society by cultivating critical awareness, ethical responsibility, and personal empowerment. As information technology continues to shape human interactions and societal structures, integrating computer science education into general education becomes increasingly vital.

Challenges in computer science education

The rapid advances in technology and computer science are not only fascinating but also challenging for education, particularly in terms of curricula design. Unlike other subjects, the constant changes in this field are unparalleled, making its educational implementation a complex task (Schubert & Schwill, 2011, p. 24). In particular, equipping the younger generation with adequate media literacy has become increasingly demanding due to the overwhelming influx of information on a global scale, often with minimal regulations (Niesyto et al., 2013, p.16). Consequently, educators face the challenge of staying up to date with the latest developments in computer science while ensuring their students receive comprehensive education.

To address these challenges, there is a growing need for dynamic educational resources that can be easily adapted and shared within the teaching community. Open educational resources (OER) offer a promising solution, as they provide freely accessible learning materials that can be modified to meet the evolving demand of computer science education.

Paradigm shift in computer science education

As early as the 1990s, experts advocated for a paradigm shift in computer science from focusing merely on its technical and engineering features to approach it as a comprehensive discipline, that examines human-computer interaction holistically (Schubert & Schwill, 2011, p. 53). Rather than being rooted solely in the core principles of computer science, this evolving approach prioritizes the broader effects of technological progress on individuals and society. Its main goals include promoting digital literacy, enabling people to use communication and information technologies thoughtfully, improving their ability to evaluate the impact of technological applications, and preparing them to navigate the challenges that arise from continuous technological advancements (Hubwieser, 2007, p. 52).

Furthermore, the integration of artificial intelligence in learning could reshape education yet again by shifting the focus from simple memorization to deeper comprehension. This transformation promotes the development of competencies such as analytical thinking and problem-solving,

equipping students with valuable skills that are applicable across diverse fields (McKeag, 2023, p. 16).

Ethical considerations in AI education

The integration of artificial intelligence (AI) into educational contexts raises significant ethical considerations that must be addressed to ensure responsible and fair usage.

In the field of machine ethics, one fundamental challenge is determining how to design AI systems capable of making moral decisions. Although AI can process data representing emotions, it currently lacks the ability to genuinely feel or be aware of those emotions. Instead, ethical decision-making in AI relies heavily on logical reasoning, which guides rational behavior (Bartneck et al., 2019, pp. 30-31). However, implementing moral competence in AI is complicated by the lack of a universally accepted moral theory. One proposed approach is to develop ethical test cases that an AI must pass to demonstrate moral competence. This would involve creating a variety of scenarios to assess fairness and ethical integrity, an area of ongoing research in AI ethics (Bartneck et al., 2019, p. 35).

The ethical challenges of AI are particularly complex in educational settings, where systems interact with children who are still developing cognitive and moral capacities. This raises concerns about children's agency, autonomy, and privacy. Adams et al. (2023, p. 5) argue that AI systems' advances in influencing human choices calls for a reassessment of human dignity and agency—especially for children. Ensuring that children can actively participate in shaping AI systems and make informed decisions about their usage is crucial for protecting their agency. This includes safeguarding children's privacy and ensuring they understand how their data is collected and used (Adams et al., 2023, p. 5). Considering fairness and equity, AI-driven tools can bring additional ethical risks for children. Research has shown that these systems can reinforce social biases, disproportionately disadvantaging students with marginalized backgrounds. Since algorithms inevitably mirror the perspectives and opinions of their creators, they may embed gender and racial prejudices, exacerbating inequalities rather than mitigating them (Akgun & Greenhow, 2022, pp. 423, 434).

To address these challenges, several ethical core principles have been identified, including transparency, justice and fairness, non-maleficence, responsibility, privacy, beneficence, and freedom and autonomy. As Adams et al. (2023, p. 1) claim, additional principles are necessary in the context of education to protect young users. These include pedagogical appropriateness, respect for children's rights, AI literacy, and consideration of teacher well-being (Adams et al., 2023, p. 1).

Pedagogical appropriateness ensures that AI applications are suitable for educational contexts, while children's rights emphasize the importance of safeguarding minors in digital environments.

A key aspect of ethical AI education is fostering AI literacy, which goes beyond technical skills to include an understanding of ethical considerations and user rights. AI literacy involves not only the competent utilization of AI systems but also the capacity to comprehend how these systems are developed, the biases inherent in data, and the ethical implications of AI usage (UNICEF, 2021, as cited in Adams et al., 2023, p. 6). This awareness contributes to critical reasoning skills essential for navigating the complexities of the information society, including an understanding of the possibilities and limitations of digital systems (Hubwieser, 2007, p. 63).

These ethical considerations highlight the importance of a comprehensive approach to AI education that empowers individuals to engage responsibly with digital systems.

Teachers' responsibility

The rapid development and integration of artificial intelligence (AI) in education bring new responsibilities for teachers, who must navigate its ethical, pedagogical, and technological implications. One of the fundamental duties of educators is to is to guide the use of AI systems in a way that nurtures students' intellectual growth. This entails the ability to critically assess how AI tools can improve learning experiences while also being mindful of its possible limitations and risks. (Adams et al., 2023, pp. 2, 5). Teachers, along with other educational stakeholders, must therefore weigh the benefits and limitations of AI in order to create a balanced learning environment that does not prioritize efficiency over depth of understanding.

A core aspect of teachers' responsibility is their own AI literacy, encompassing both technological and pedagogical expertise. Effective integration of AI requires educators to develop AI-specific knowledge, enabling them to evaluate and justify AI-driven outcomes (Celik, 2023, pp. 2, 7). This is particularly crucial given the ethical concerns that AI introduces into educational settings. Teachers must be equipped to critically evaluate AI-generated decisions, ensuring that they align with educational values such as inclusivity, fairness, and transparency. Moreover, beyond their own understanding, educators play a pivotal role in fostering AI literacy among students. By teaching young learners about AI's capabilities and limitations, teachers empower them to navigate AI technologies critically for their own use (Adams et al., 2023, p. 6).

AI should not be perceived as a disruption to traditional education, but instead it should be acknowledged as a valuable aid that enhances learning while maintaining the development of foundational skills. AI provides opportunities for personalized learning, innovative materials, and

reducing the organizational workload, allowing students to focus on critical thinking and creativity (McKeag, 2023, p. 14). However, the challenge lies in the responsible and ethical integration of AI in the classroom. Excluding AI tools is neither practical nor beneficial; instead, educators must develop strategies to guide students in using AI while upholding academic equity (McKeag, 2023, p. 20).

One of the most effective ways to promote ethical AI use is by engaging students in conversations about its implications. Teachers should create opportunities for students to explore AI's impact on education, reflect on potential ethical dilemmas, and debate responsible usage guidelines. Establishing regular classroom discussions on such topics fosters a critical awareness among students. By providing a safe and open forum for these debates, educators help students develop a nuanced understanding of AI's ethical dimensions, ensuring they are better prepared to navigate an AI-driven world (McKeag, 2023, p. 20-22).

Ultimately, the responsibility of teachers in AI education extends beyond technical knowledge to encompass ethical AI literacy and student empowerment. By carefully integrating AI into their pedagogical approaches, maintaining ethical oversight, and facilitating critical discussions, educators can help shape a future generation that is both technologically proficient and ethically conscious.

3.2. Open Educational Resources

As noted by Hubwieser (2007, p. 78), high quality teaching materials are essential to cover the curriculum requirements. He outlines several key criteria that educational resources should fulfill to ensure their effectiveness (Hubwieser, 2007, p. 83):

- *Horizontal criterion*: broad applicability and observability
- *Vertical criterion*: suitability for a wide age range
- *Criterion of time:* long-term relevance and appropriateness
- *Criterion of sense:* impact on real life language and thinking

Ensuring that teaching materials align with these criteria can be challenging, particularly in rapidly evolving subjects like computer science. The concept of Open Educational Resources (OER) offers an opportunity for quality assurance in relation to these and many other criteria, ensuring that educational materials remain adaptable, accessible, and relevant.

Definition

Open Educational Resources (OER) are educational materials made freely available for use, adaptation, and redistribution, promoting access to knowledge and learning without the typical barriers of cost or restrictive licensing. The term OER was first defined by the UNESCO in 2002 as *"the open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for noncommercial purposes."* (UNESCO, 2002, p. 24) This early vision highlighted four key elements: free access, available through digital technologies, involvement of a varied user population, and a focus on improving teaching and learning rather than making profits.

Building on this foundational idea, the Organization for Economic Cooperation and Development (OECD) expanded the understanding of OER in 2007 by attributing three main components to them: *learning content* (comprehensive educational materials), *tools* (applications that facilitate distribution and reusability), and *implementation resources* (establishing open access, guidelines for utilization) (OECD, 2007, pp. 30-31). This classification provides a more structured framework, reflecting the growing complexity of the OER landscape as digital technologies advanced.

Over time, the definition of OER has evolved to reflect advancements in digital technology and the growing movement towards open access. In 2019, UNESCO updated its definition of OER to include educational resources "*in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaption and redistribution by others*." (UNESCO, 2019, p. 5) This new definition underscores the transformative role of ICT in enhancing unrestricted access to educational materials worldwide. Moreover, UNESCO identified five key goals to support the development and sustainability of OER: empowering stakeholders to effectively use OER, creating supporting policy frameworks, guaranteeing inclusive and high-quality resources, promoting sustainable practices, and advancing global collaboration (UNESCO, 2019). These objectives emphasize OER's potential to make education more accessible while also fostering global knowledge exchange and cooperation (UNESCO, 2019, p.6).

A comprehensive understanding of the concept OER requires an examination of the individual terms which it is composed of. Simão de Deus and Barbosa (2022, pp. 450-451) clarify that the term *open* refers to flexible licensing that permits free access, use, and modification with few limitations, while *educational* defines the intent of the resources for "teaching, learning, or research". As for *resources*, OER can take many forms, as any digital material designed for educational use qualifies as an open educational resource.

To conclude, OER are more than just freely available educational materials; they are a transformative approach to education enabled by digital technologies and supported by open licensing. As definitions and frameworks continue to evolve, the focus remains on accessibility, adaptability, and collaboration, ensuring that educational resources serve a diverse, global community of learners and educators.

OER's potential in education

Open Educational Resources offer significant opportunities to enhance education by encouraging collaboration and inclusivity. By enabling stakeholders to actively contribute to and customize educational content, OER shift traditional roles and foster more interactive learning experiences (UNESCO, 2019, pp. 6-7). This approach supports the continuous improvement and diversification of curricula, as educational materials can be adapted to different contexts and learning needs. Consequently, OER facilitate the use of varied teaching strategies and innovative assessments, creating more engaging and relevant educational environments (UNESCO, 2019, p. 7).

The open nature of OER also accelerates the spread of knowledge, connecting diverse communities of learners and educators. It enables wider access to information, which not only engages more experts in problem-solving but also speeds up the enhancement of educational quality (OECD, 2007). This collaborative development process improves the reliability and effectiveness of educational resources while also reducing inequalities in access to learning opportunities (UNESCO, 2019, p. 5; OECD, 2007, p.58).

On a more personal level, participation in the creation and sharing of OER can enhance an individual's professional visibility and reputation, fostering a sense of community and shared purpose among educators and learners (OECD, 2007, p. 58). By combining adaptable content with open licensing, OER encourage ongoing collaboration, knowledge-sharing, and innovation, ultimately supporting a more interconnected and equitable global educational landscape.

OER quality criteria after Zawacki-Richter and Mayrberger

The open nature of OER requires guidelines to uphold a certain standard. Zawacki-Richer and Mayrberger (2017) determined three main categories and several subcategories for assessing the quality of OER (see Figure 1). The resulting quality criteria are used as a reference for answering the third research question of the present study, i.e. assessing the OER materials. This source was selected for its critical evaluation and identification of 161 criteria across eight different frameworks, each differing in complexity, detail-orientation, and number of values.

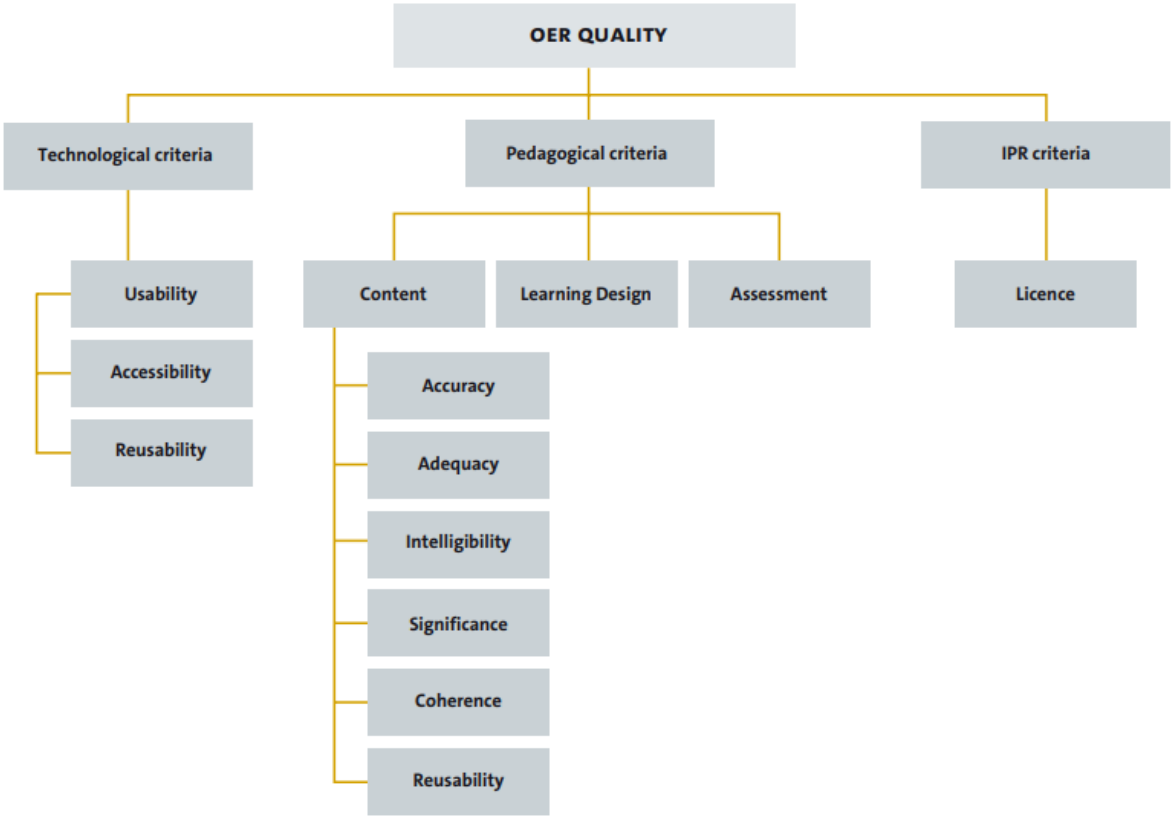

Figure 1: OER quality criteria (Zawacki-Richter & Mayrberger, 2017, p. 39)

Technological criteria

The technological criteria include three main aspects: usability, accessibility and reusability.

1. *Usability* relates to the intuitive handling and design of the OERs, addressing features such as straightforward navigation, clear organization of content, user-friendly interfaces as well as other visual attributes of the material. Another relevant component is technological interactivity, which supports students in their learning and general engagement during the lesson.
2. *Accessibility* ensures the availability and usability of OERs relying on technical reliability and compatibility with different platforms and devices, considering accessibility for learners with disabilities.
3. *Reusability* focuses on compliance with international standards, such as IEEE, which allows reiteration, modification and merging of materials. (Zawacki-Richter & Mayrberger, 2017, p. 40)

Pedagogical criteria

Pedagogical-didactical criteria are recognized as crucial for evaluating the quality of OERs.

1. The quality of *content* involves six aspects; the content must be accurate, complete and current (accuracy), appropriate for the audience and adequately presented (adequacy), and easily understandable (intelligibility). Moreover, the content must be relevant and scientifically sound (significance), introduced in a coherent and logical manner, and adjustable in different contexts (reusability).
2. *Learning Design* describes a structured organization and design of learning processes, featuring learning goals, methods, content and media use, all designed to support effective learning. The teaching concept addresses a specific target group while taking into account their existing knowledge and skills. Teaching goals need to be transparent and in correspondence with the subject's lesson activities and assessment. Students should be encouraged to collaborate with their peers, creating a motivating and engaging atmosphere. Additionally, the integration of various media promotes higher interest in the subject matter. Not only should OERs meet the respective educational standards but also allow learners to apply their gained knowledge on real life problems and contexts. Fulfilling these criteria ensures an engaging and goal-oriented learning environment.
3. The category *assessment* suggests that OERs should enable teachers to evaluate students, while also providing learners with opportunities to receive feedback. (Zawacki-Richter & Mayrberger, 2017, pp. 41-44)

Intellectual property (IPR) criteria

Intellectual property criteria highlight the importance of using open licenses, as it is interconnected with other aspects such as accessibility and reusability. These licenses need to be integrated into the materials in a legitimate and transparent manner, ensuring compliance with legal standards. (Zawacki-Richter & Mayrberger, 2017, p. 44)

3.3. Digital competencies

When planning and conducting a lesson, it is crucial to carefully consider the skills and knowledge participating students are expected to acquire. In modern education, terms such as "future-ready skills" or "21st century skills" have emerged to summarize a collection of competences necessary for navigating an increasingly complex and technology-driven global landscape. These competences include "adaptability, collaboration, communication, critical thinking, problem-solving, digital literacy, and cultural competency" (McKeag, 2023, p. 19). By integrating these skills into lesson planning, educators can ensure that students are equipped not only with subject-specific knowledge but also with the tools needed to succeed in a continuously advancing society.

A crucial aspect of digital literacy is media competency, which involves not only understanding the technical and aesthetic foundations of various media but also recognizing their societal, cultural, economic, and political impact. Media competency enables students to critically analyze and responsibly engage with media by making informed choices and using media thoughtfully in academic, professional, and personal contexts. Additionally, it fosters the ability to actively and creatively produce media content for self-expression, communication, and participation in digital discourse (Niesyto et al., 2013, p. 15). The lesson materials for AI & Art and Fake News & Posts specifically target media competencies engaging students in the analysis and creation of digital media elements.

Figure 2 below displays the Digital Competence Framework for Citizens (DigComp) attempting to define digital competence and establish a European standard to measure it. A refined definition goes as follows:

> *"Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking." (European Commission: Directorate-General for Education, Youth, Sport and Culture, 2019, p. 10).*

Six categories (*Foundations, access and digital understanding; Information & Data; Communication, interaction & Collaboration; Digital content creation, production and publication; Safety and sustainable use of resources; Problem solving, innovation and continuous learning*) and their respective subcategories reveal the variety of competencies addressed in the field. The main categories may be tied to particular practices, but some also apply across various contexts without requiring a specific setting. This implies that the framework's competences do not only refer to practical skills, but also knowledge and attitudes. This is particularly relevant for the present study, since the researched OER's focus on ethics resulted in a considerable amount of information input, discussion and reflection besides working with tools and developing skills. It is important to establish interrelations amongst different key competencies rather than perceiving them isolated from one another, highlighting the need for a combination of competencies in order to successfully apply them on real world contexts (Federal Chancellery of Austria, 2024, p. 6).

Figure 2: The digital competencies framework for citizens (DigComp 2.3) (OeAD, 2024, Retrieved April 15, 2025 from https://oead.at/en/expertise/digcomp-zuordnung/kompetenzmodell)

The table below lists the competences addressed across the four tested OER, indicating the tools and activities associated with them. It is to mention that the framework was updated while this thesis was written. There were some minor changes within categories 1-5 and category 0 was newly added. This allowed for a quick adjustment of table 1 to reflect the current standard in the field of competence development.

Table 1: Competences addressed by tested OERs (cf. Ambros et al., 2024, p. 7)

OER	DigComp 2.3 Competences	Tools/Activities
Autonomous vehicles (AV)	0.2, 2.2, 2.3, 2.5	Answergarden
	0.2, 0.4	Moral Machine

	0.2, 0.4, 2.5	Kahoot Team, Debate
Teaching and learning with AI (TL AI)	0.2, 0.4, 1.2	ChatGPT, Google Translate, DeepL
	0.2, 2.2, 2.3, 2.5	Mentimeter, Padlet
AI and Art (AI & A)	0.2, 2.2, 2.3, 2.5	Answergarden, Padlet
	0.2, 3.1, 5.3	Image generator
Fake News and Posts (FNP)	0.2, 1.2	Fakefinder
	0.2, 2.2, 2.3, 2.5	Mentimeter, Padlet
	0.2, 3.1, 5.3	Generating fake posts

3.4. Design-based research

The underlying methodology of this thesis is a design-based research approach which is explained further below.

Origins and Rationale

Design research, as an overarching methodological approach, has evolved as a consequence of observed limitations of traditional educational research in terms of practical relevance (Euler, 2014, p. 16). The issues addressed by design research may originate from challenges encountered by practitioners in their professional environments or from theoretically driven problems that require innovative solutions. (Brahm & Jenert, 2014, p. 46). Over the past two decades, various terms have been associated with this research orientation, including "design-based research" (Design-Based Research Collective, 2003) and "educational design research" (McKenney & Reeves, 2019). Despite differences in terminology, these approaches share a common goal: to bridge the gap between research and educational practice by systematically analyzing, designing, and evaluating interventions.

According to a definition provided by Plomp (2013, p. 16), design research is *"the systematic analysis, design and evaluation of educational interventions with the dual aim of generating research-based solutions for complex problems in educational practice, and advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them."*

This definition highlights the two-fold function of design research—addressing practical challenges and contributing to theoretical advancements.

The emergence of design research was driven by the need for a paradigm that not only describes and explains existing educational phenomena but also actively engages in innovating and developing potential solutions (Euler, 2014, p. 16). A key characteristic of this methodology is its emphasis on "iterative cycles" of research and development, which include "design, testing, analysis, and redesign" (Euler, 2014, p. 19). Various process models exist, yet they all share a fundamental structure in which solutions evolve incrementally while being continuously assessed and refined. The illustration below depicts the phases of a design research procedure while detecting the intended outcomes for each stage.

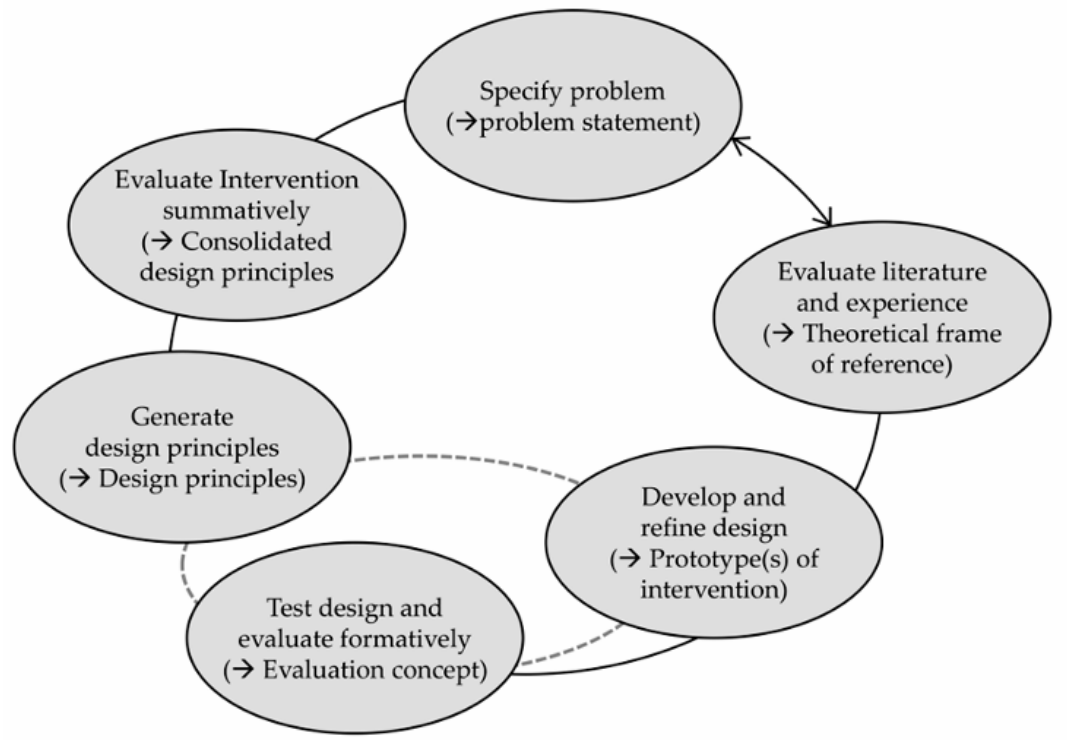

Figure 3: Research and development cycles in the design research context (Euler, 2014, p. 20)

The legitimacy of design research as a methodological paradigm is reinforced by its commitment to practical relevance and scientific innovation. Euler (2014, pp. 17-18) identifies five core elements that frame design research:

- "*Discovering, developing, and testing innovative solutions for unsolved practical problems*
- *Theory-based development*
- *High practical relevance through iterative design cycles*
- *Cooperation between researchers and practitioners*
- *Area-specific theories as targeted outcomes*"

These principles underscore the iterative, collaborative, and practice-oriented nature of design research. By systematically addressing real-world educational challenges while simultaneously generating theoretical insights, design-based research establishes itself as a robust and dynamic approach within the field of educational research.

The educational design research model by McKenney & Reeves (Figure 4) is intentionally structured to be adaptable across different approaches by incorporating only its fundamental elements. It consists of three key phases—investigation and analysis, design and prototyping, and evaluation and retrospection—which follow a flexible and iterative process. Iteration is emphasized through continuous feedback loops between phases, while flexibility allows for multiple possible sequence orders (McKenney & Reeves, 2019, p. 83).

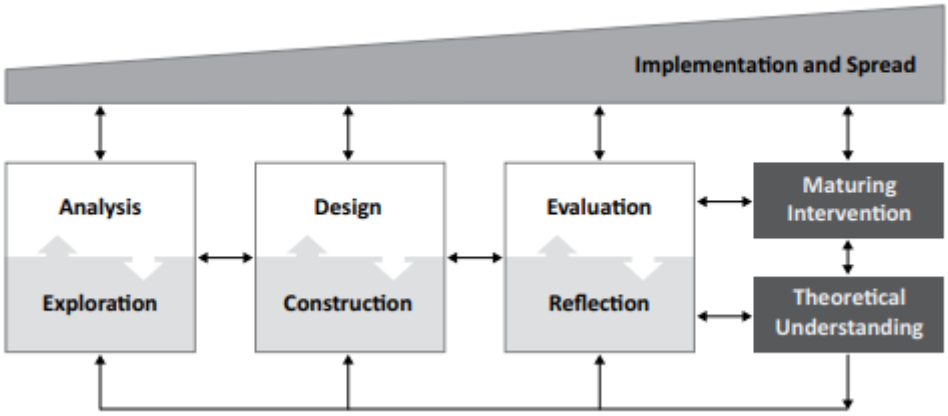

Figure 4: Generic model for conducting design research in education (McKenney & Reeves, 2019, p. 83)

Again, the defining characteristic of this model is its "dual focus on theory and practice", represented by distinct elements for research (white) and design processes (grey), leading to both scientific and practical outcomes. Additionally, the model is "use-inspired", meaning it is designed for real-world application. This is illustrated by the emphasis on implementation and dissemination, where practical engagement occurs from the outset and expands gradually. The reciprocal nature of the model establishes contextual responsiveness, demonstrating that practice influences research just as much as research informs practice (McKenney & Reeves, 2019, p. 83).

Design-based research (DBR) aligns closely with design research and educational design research, sharing their focus on bridging theory and practice through iterative development processes. It is defined as *"a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories"*

(Wang & Hannafin, 2005, pp. 6-7). Like other design-oriented approaches, DBR progresses through multiple iterative phases, continuously refining initial solutions to develop robust instructional designs while contributing to educational theory (Brahm & Jenert, 2014, p. 46). It can be described as progressive and reflective, as designs are grounded in theoretical models and refined based on empirical insights, ensuring ongoing evaluation and adaptation (Rudloff, 2023, p. 17).

DBR is characterized by five key principles: it is "pragmatic, grounded, interactive and iterative, integrative, and contextual" (Wang & Hannafin, 2005, p. 7). These elements highlight DBR's role in tackling complex educational challenges while simultaneously contributing to the advancement of research and practice within the broader field of design research.

Table 2: Characteristics of design-based research (Wang & Hannafin, 2005, p. 8)

Characteristics	**Explanations**
Pragmatic	• Advances both theory and practice • Theory valued for its practical impact
Grounded	• Design is rooted in research and theory. • Design is conducted in authentic environments and research is integrated into the design process.
Interactive, iterative, and flexible	• Collaboration of researcher and participants. • Designs are refined through continuous cycles. • Plans remain adaptable.
Integrative	• Uses mixed methods • Evolving as research progresses while maintaining rigor
Contextual	• Documents the process, findings, and adaptations • Research is linked to design process and environment. • Capacity of design principles varies. • Requiring application guidance for developed principles

Quality criteria

Ensuring the quality of a DBR project requires adherence to several key criteria that balance both, practical relevance and scientific rigor. A fundamental principle is the focus on developing innovative solutions and meaningful pedagogical advancements, connecting theory and learning (The

Design-Based Research Collective, 2003, p. 5). Similarly, Anderson and Shattuck (2012, pp. 16-17) argue that DBR must "focus on the design and testing of a significant intervention". Both research groups report that interventions should take place in authentic educational settings, ensuring they are not only theoretically sound but also practically significant. Moreover, they highlight the necessity of multiple design cycles in which interventions are continuously tested and refined through iterative processes, further strengthening their relevance and effectiveness.

Another critical aspect of DBR quality is its contribution to broader academic and professional discourse. The Design-Based Research Collective (2003, p. 5) asserts that high-quality DBR studies must produce knowledge, which can be exchanged effectively with other researchers and educators. This idea aligns with Anderson and Shattuck's (2012, pp. 16-17) emphasis on generating evolving design principles that can guide future research and practice. In both frameworks, collaboration between researchers and practitioners is seen as indispensable, as it bridges the gap between theoretical inquiry and applied educational challenges. Furthermore, both emphasize methodological rigor through the use of mixed methods, providing a comprehensive evaluation of the intervention's impact.

Finally, Brahm and Jenert (2014, p. 50) introduce two overarching quality criteria: the educational relevance of the problem, intervention and resolution, and the scientific validity of the theoretical contributions derived from research. By adhering to these criteria – situating research in real-world contexts, engaging in iterative refinement, fostering collaboration, and ensuing methodological rigor – DBR maintains its dual commitment to advancing educational practice and contributing to scientific knowledge.

Ultimately, these criteria reinforce DBR's value as a methodology that not only addresses immediate educational challenges but also generates lasting theoretical and practical contributions.

Goals

DBR aims to develop and refine educational interventions that improve learning environments by taking the impact on various stakeholders into consideration. By designing, testing, and refining interventions within authentic educational settings, DBR facilitates the adoption of innovative teaching and learning strategies while ensuring their practical viability (The Design-Based Research Collective, 2003, p. 8; Brahm & Jenert, 2014, p. 54).

According to Euler (2014, p.17), DBR investigates how best to achieve desired learning outcomes through newly developed innovations. This approach not only enhances specific learning environments but also contributes to the development of "prototheories" that can be applied across

different educational settings (Euler, 2014, pp. 17-18; Harlow et al., 2019, p. 227). The iterative nature of DBR allows for continuous refinement of educational designs, ensuring their broader applicability (Euler, 2014, p. 17).

Beyond its practical impact, DBR strengthens the reciprocal relationship between scientific theory and educational practice. By drawing research topics from real-world problems and using scientific theories to develop effective solutions, DBR fosters advancements that benefit both domains (Euler, 2014, p. 21; Brahm & Jenert, 2014, p. 46).

Benefits of DBR

DBR offers significant advantages in educational research by actively shaping curricula, pedagogical strategies, and learning environments, making it a powerful tool for educational innovation (Harlow et al., 2018, p. 226). One of its primary strengths lies in its ability to enhance the innovative capacity of educational research while maintaining a strong connection to authentic teaching and learning practices (Rudloff, 2023, p. 17). Unlike traditional research methodologies that focus solely on theoretical advancements, DBR ensures that its findings are directly applicable to educational settings, bridging the gap between research and practice.

A key benefit of DBR is its capacity to enhance "design, research, and practice" in a simultaneous iterative manner (Wang & Hannafin, 2005, p. 5). DBR positions educational designs as theoretical constructs that reflect deeper insights into teaching and learning (Design-Based Research Collective, 2003, p. 6). By systematically developing and improving interventions within educational settings, DBR ensures that research outcomes are both theoretically grounded and pragmatically valuable (Wang & Hannafin, 2005, p. 6).

Furthermore, the iterative cycles of DBR allow for continuous improvement, with insights from each phase informing subsequent refinements (McKenney & Reeves, 2014, p. 152 in Euler). This approach not only enhances the effectiveness of educational interventions but also contributes to the evolution of broader design principles. By integrating theory, practice, and design in an iterative and collaborative manner, DBR remains a valuable methodology for advancing both educational research and instructional development.

4. Methods

4.1. Research Design based on the DBR-Framework

Design-Based Research (DBR) was chosen as the methodological framework for this study due to its practice-oriented approach to developing and refining educational interventions. The process

unfolds in repeated cycles of "design, testing, analysis, and redesign", ensuring that interventions are continuously adapted based on empirical insights (Euler, 2014, p. 19). DBR involves four core phases – **Analysis and Exploration**, **Design and Construction**, **Evaluation and Reflection** and **Theoretical Understanding and Discussion** – which allow for systematic testing and refinement of interventions in authentic settings (McKenney & Reeves, 2014, p. 142).

The figure below illustrates the procedure used for this study (cf. McKenney & Reeves, 2014/2019; Raval & McKenney & Pieters, 2014; Rudloff, 2023). In the *analysis and construction phase*, a thorough analysis of needs, conditions, and contextual factors is conducted to establish a theoretical foundation and identify relevant constraints for the intervention's design (Brahm & Jenert, 2014, p. 49; Rudloff, 2023, pp. 173-174). The *design and construction phase* focuses on developing a prototype that integrates existing theories and practical considerations while addressing the specific teaching-learning context (Brahm & Jenert, 2014, p. 49; Rudloff, 2023, pp. 174-175). The *evaluation and reflection phase* consists of iterative cycles of implementation, assessment, and revision. Each iteration informs subsequent refinements, ensuring continuous improvement. Ultimately, the final intervention undergoes summative evaluation to determine its effectiveness in achieving the initially defined objectives (Brahm & Jenert in Euler, 2014, p. 49; Rudloff, 2023, p. 175). Findings from this process contribute both to *theoretical understanding* and practical application by offering evidence-based recommendations for future implementations (Brahm & Jenert in Euler, 2014, p. 49; Rudloff, 2023, p. 175).

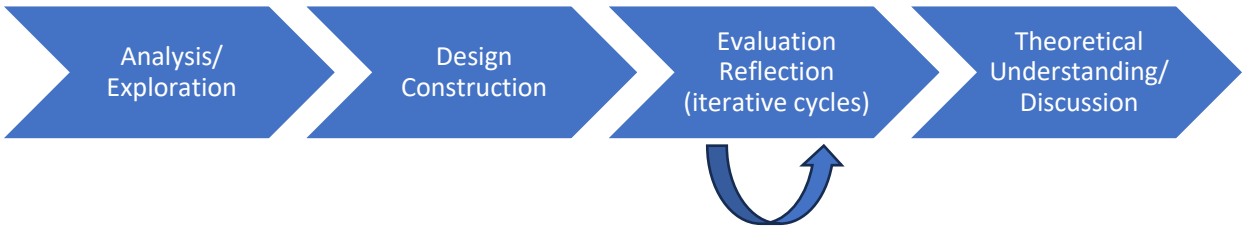

Figure 5: Design-Based Research Process (adapted form McKenney & Reeves, 2014; Rudloff, 2023)

This model was selected because it closely aligns with the structure of the empirical part of this thesis. The analysis phase corresponds to examining the context of intervention, while the design construction phase features the lesson materials provided by university students. The evaluation phase consists of two intervention cycles in school, and the theoretical understanding phase eventually focuses on discussing the study's outcomes. Unlike other models in design research, where iteration may occur throughout the entire process, this study emphasizes iteration primarily within the evaluation/reflection phase. Outside of this phase, a more linear structure was adopted for the

procedure to provide a clearer overview of the individual phases and to better accommodate the timeframe and workload constraints of a Master's thesis.

4.2. Data Collection

The empirical part of this study was conducted during two periods: November/December 2023 (first teaching cycle) and September/October 2024 (second teaching cycle). Data for this research was collected through questionnaires, observation notes and mentor feedback.

The questionnaires were shared via Microsoft Forms, including both qualitative and quantitative questions. The subjects for the survey were fifth-grade students at GRG 21 in Vienna. They were given a questionnaire before and after each lesson to gauge any changes in knowledge or opinion. The survey questions were adapted according to the specific lesson topics. The class teacher received the results with the subjects' names, allowing them to connect the pre- and post-lesson questionnaires. The data was then anonymized and handed to the researcher.

During the first teaching cycle, four lesson plans were carried out across three different groups. Table 3 shows the number of usable questionnaire pairs that were considered for the evaluation. Responses from participants who only completed one questionnaire were excluded from the evaluation.

- AV: 33 (5a: 2 missed doing the post-q, 5d: 1 person handed the q in twice, 2 missed doing the post-q) -> n=28
- TL AI: 31 (5d: 1 missed doing the post-q) -> n=30
- AI & A: 29 (5a: 1 missed doing the pre-q, 1 only ticked value zero, 5d: 1 handed in q twice) -> n=26
- FNP: 19 (5d: 2 missed doing the post-q, 5c: 2 missed doing the post-q) -> n=15

Table 3: Number of participants - first teaching cycle

Class	**AV (n)**	**TL AI (n)**	**AI & A (n)**	**FNP (n)**
5A	10	9	9	-
5C	8	10	6	6
5D	10	11	11	9
Total	**28**	**30**	**26**	**15**

After the first testing phase, the materials and methods were examined and adjusted as needed. Some changes were also made to the questionnaires, including the addition of questions to generate more before-and-after comparisons, as well as the elimination of others to ensure participants could complete the surveys thoughtfully without feeling overwhelmed by the number of questions. Once the redesigning process was finished and the new school year had started the lessons were retested in the new classes at the same grade level.

During the second teaching cycle, two lesson plans were carried out across two different groups due to time limitations and schedule issues. Although they were separated in certain subjects, such as computer science, the two tested groups formed one class, unlike the first cycle, where the tested groups each came from different classes. Lesson plans AV and TL AI were chosen as they were found to have brought the most interesting data and covered important topics for the students. Additionally, they had the most potential for an effective redesign. Fortunately, all the questionnaires were admissible as all participants completed both surveys (see Table 4).

Table 4: Number of participants - second teaching cycle

Class	**AV (n)**	**TL AI (n)**
5D_1	12	10
5D_2	9	11
Total	**21**	**21**

Additionally, observation notes were taken regarding student engagement, the materials' efficacy and teacher performance after the individual lessons. The mentor/class teacher supervised the lessons but took on a passive role, leaving the teaching responsibility entirely to the trainee. Following each lesson, a feedback session was held to reflect on the lesson and discuss possible improvements in both the teaching concepts and the teaching style.

4.3. Data analysis

As mentioned earlier, the presented study follows the DBR framework as its research methodology. The third stage of this framework requires evaluation and reflection in an iterative manner. A mixed-method approach is commonly employed in design research since quantitative analysis may be used for assessing the effectiveness of interventions, while qualitative analysis is suggested for the formative documentation of the context and research process (Euler, 2014, p. 50). Similarly, this study integrates multiple methods, combining a descriptive analysis (cf. Bell, 2018, p.15) of

the questionnaires' closed questions and a qualitative analysis of the questionnaires' open questions. For the latter, a keyword search was conducted, and related terms were color-coded for clarity. The frequency of the keywords was then recorded, and subsequent patterns and trends were analyzed. This approach reduced researcher bias by systematically analyzing responses rather than relying on subjective interpretation. Based on the analysis, conclusions were drawn regarding the content's underlying themes and implications, providing deeper insight into the data (cf. Creswell, 2022, pp. 207-208). This data served as a base for a comprehensive reflection which additionally considered observation notes and the mentor's feedback on the interventions. Overall, the evaluation served both a formative and summative purpose: it aimed to enhance the teaching designs, while evaluating the materials' effectiveness on a broader scale (McKenney & Reeves 2014: 143 in Euler).

5. Results according to DBR

5.1. Analysis/Exploration

The motive for this research initially emerged at the outset of the mandatory practicum within the teacher training program at the University of Vienna. In this setting, the author of this thesis assumed the role of the mentee and had not only an interest in the didactics of computer science but also in the (re)usability and optimization of teaching materials. The assigned mentor at the practicum school happened to be an active researcher at the university, in search of someone to assess the quality of lesson materials created by university students. This led to a mutually beneficial collaboration. On the one hand, the mentor gained the opportunity to have said materials critically assessed and refined by a third party, ensuring their effectiveness and long-term reusability. On the other hand, the mentee gained valuable insights into the principles of instructional design, deepening their understanding of how to create high-quality, adaptable teaching resources. Beyond this immediate exchange, the collaboration fostered a broader reflection on best practices in lesson material development, applying theoretical knowledge into the classroom environment.

In this study, as in many other DBR procedures, the researcher took on multiple roles throughout the process – acting not only as a designer and educator but also as an investigator and analyst. While this dynamic involvement offers the advantage of being deeply involved in the research process, it also raises concerns about potential biases (McKenney & Reeves, 2014, pp. 147-148). To address these challenges, the study incorporated divers data sources and maintained rigorous documentation of the research process, ensuring transparency and enhancing the validity of the findings.

The first teaching cycle took place during the mandatory practicum required by the university's teacher training program. By the time of the second cycle, the former teacher trainee was already employed at a different school than the one in the study. This shift in position and experience meant that while the researcher's role had evolved, the subjects still perceived them as an external teaching assistant, maintaining the same status in their point of view. Importantly, there was no direct connection with the school, minimizing bias towards the teacher and ensuring that the focus remained on the educational concepts being tested.

The OER examined in this study share a common theme: AI and ethics. This topic aligns with the Austrian curriculum for secondary schools (AHS Lehrplan, 2025) as part of the section: impact of computer science on humans and society ("*Mensch und Gesellschaft*"). The curriculum emphasizes that students should gain an understanding of effects, possibilities, limitations, and risks associated with emerging technologies ("*Durch die Beschäftigung mit diesen Technologien lernen Schülerinnen und Schüler deren Auswirkungen, Möglichkeiten, Grenzen und Gefahren kennen*."). Moreover, the curriculum also highlights the importance of critical thinking and self-awareness in students. It encourages them to recognize the unique capabilities of human cognition, emotion, and agency—qualities that distinguish them from machines. This, in turn, underscores the need for a responsible and ethical approach to interacting with information technologies: ("*Die Schülerinnen und Schüler erkennen das Potenzial ihrer eigenen Fähigkeiten als denkende, handelnde, fühlende und sich entwickelnde Menschen im Unterschied zu einer lernenden Maschine. Dies erfordert einen verantwortungsvollen Umgang mit Informationstechnologien.*"). By integrating AI and ethics into the curriculum, students are not only exposed to the technical aspects of artificial intelligence but also to its broader societal implications. This holistic approach aims to prepare them for an increasingly digital world, fostering both digital literacy and ethical responsibility.

5.2. Design Construction of OER Materials

The following materials were designed by teacher training students as an assignment for a didactics class at the University of Vienna, focused on active student engagement and ethical reflection. As McKeag (2023, pp. 20-22) highlights, creating an inclusive and reflective classroom environment is essential for integrating artificial intelligence (AI) in education responsibly. By encouraging discussions on AI's ethical implications and involving students in critical thinking exercises, educators can create a space where learners actively participate in defining AI's role in their own learning processes. This aligns with constructivist approaches, which stress the necessity of first developing problem awareness before presenting solutions, allowing students to construct knowledge through meaningful engagement (Hubwieser, 2007, p. 67). Furthermore, embedding

learning in authentic problem situations—where students apply problem-solving skills in relevant contexts—enhances their ability to navigate real-world challenges. Within this framework, the present materials serve as an empirical basis for examining how such pedagogical principles are applied in practice.

5.2.1. Autonomous vehicles

Prototype 1: Design

This lesson plan was designed for a 50-minute session on the upper secondary level. It has five sections:

1. Introduction to the topic: lecture-style
2. Exploring a new tool: Moral Machine
3. Brainstorm and discussion: Advantages and disadvantages of self-driving cars
4. Group work: Levels of autonomous vehicles
5. Conclusion: Kahoot quiz

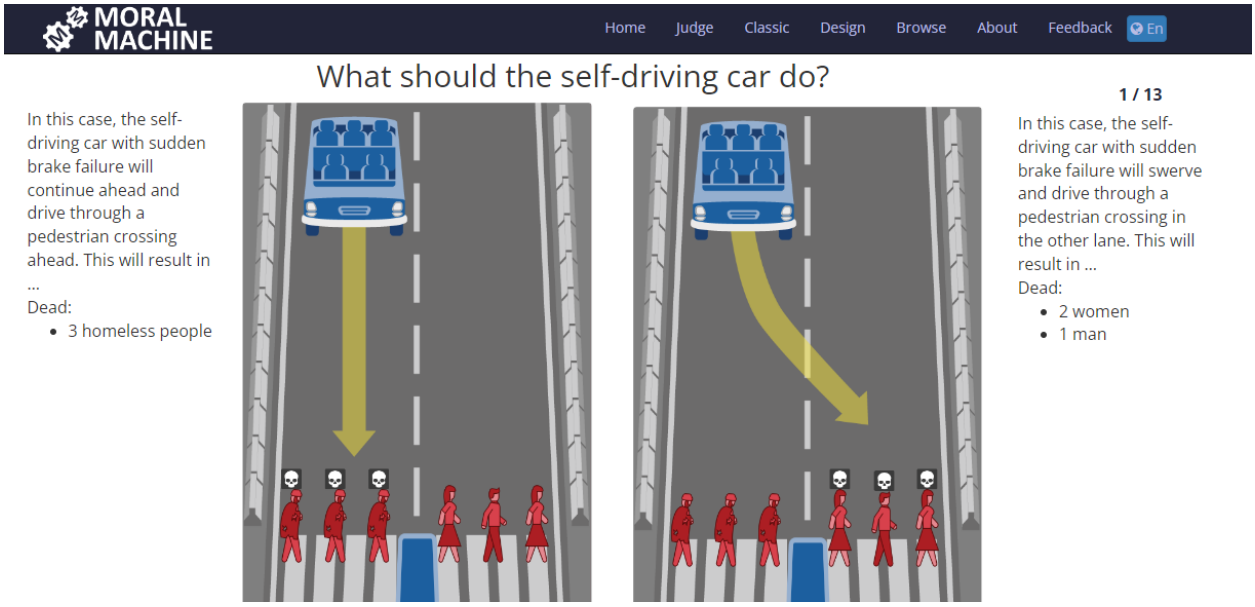

Figure 6: Moral Machine Scenario (https://www.moralmachine.net/)

In the introduction, the teacher is advised to give an overview of the topic by briefly explaining the technology behind autonomous driving and raising awareness about the moral and ethical aspects of it. With this, they can create a connection to the first activity, which is the Moral Machine. Its use is for free and there is no registration needed. Firstly, the students should try out the tool themselves. It essentially puts them in the shoes of a self-driving car and asks them to decide between two scenarios that both lead to an accident. Afterwards, the teacher gives instructions to

decide based on the law, always saving the people in the car or the people walking on the street (and so on). The whole process is accompanied by discussion and reflection about how the students feel about the decision making and what changed in their results when they considered certain rules.

After that first phase, students are introduced to the tool Answergarden, which produces wordclouds, to which they can contribute anonymously. They are asked the following question: "Which jobs would be redundant, if the use of autonomous vehicles increases?". After discussing the students' contributions, the teacher separates the class into two groups: "advantages" and "disadvantages". The students are provided with two additional Answergardens, one for each group. Now, the teacher projects the video "What if autonomous vehicles determined our streets?" [YouTube, translated from German] and asks the students to fill their respective Answergarden while watching with information from the video. They are also encouraged to post additional pros and cons which do not appear in the clip.

After forming groups of five, the students are now asked to individually read two texts about the levels of self-driving cars. Each student is assigned one level to read about, becoming an "expert" in their area. When they get back together in their groups, they are asked to share what they have learned with the other members of the group.

As a conclusion, the students take part in a Kahoot quiz as a group.

5.2.2. Teaching and learning with AI

Prototype 1: Design

This lesson plan was designed for a 100-minute session on the upper secondary level. It has four sections:

1. Introduction: Brainstorming on AI in everyday live
2. Theoretical input: lecture on AI mechanics by teacher
3. Brainstorming: Mentimeter (AI in everyday life)
4. Exploring new tools: ChatGPT, DeepL
5. Conclusion: discussion

The TL-AI lesson begins with an interactive brainstorming session on the board, where students explore and identify various ways AI is integrated into everyday life. This is followed by a brief introduction to the mechanics of AI, delivered by the teacher with the aid of a PowerPoint presentation that provides visual and conceptual support.

The theoretical input is followed by yet another brainstorming activity, this time using the tool “Mentimeter”. It is anonymous and produces a wordcloud, similar to the Answergarden tool.

The hands-on practice portion of the lesson involves students working with AI-based tools. They may also work in pairs. The first activity focuses on using ChatGPT to correct a provided text. After completing the task, students are required to share the advantages and disadvantages of using ChatGPT for text correction on a prepared Padlet. Moving on, the teacher provides an English text (considering that this lesson is taught in German) for the students to translate with the DeepL translator. Lastly, the students are asked to use ChatGPT again and summarize a prompt text. After each activity, discussions are held to allow students to share their individual experiences and insights, fostering a collaborative learning environment.

To conclude the session, impulse questions drawn from the lesson materials are offered to open up a plenary discussion or, alternatively, could be used as prompts for a student survey conducted on the "Mentimeter" platform. Some of these questions provided are:

- *“Do you think AI could replace the job of tutors?”*
- *“Do you think it is fair to use ChatGPT for schoolwork?”*
- *“Do you think that children will unlearn to think for themselves because of AI?”*

5.2.3. AI and Art

Prototype 1: Design

This lesson plan was designed for a 50-minute session on the upper secondary level. It has four sections:

1. Introduction: presenting a website selling AI-generated art
2. Exploring a new tool: generating images on BingImageCreator
3. Brainstorming and discussion: challenges and potentials of AI-generated art
4. Conclusion: discussing text on AI & art

For the AI&A lesson, the session begins with the display of a website offering AI-generated art, which is used to introduce the topic and prompt students to share their opinions on the business model behind it.

Following this introduction, students are tasked with using Bing Image Creator to generate their own pieces of "art" after which a plenary discussion is held to review and reflect on their creations.

The next phase of the lesson involves a brainstorming session, where students use the tool Answergarden to compile a list of the pros and cons of AI-generated art.

To deepen the discussion, students are then presented with a philosophical text that explores the broader impact of AI on the art world. This text serves as the foundation for the lesson's conclusion, igniting further conversation on the implications of AI's role in creative expression and its potential influence on the future of art.

5.2.4. Fake News and Posts

Prototype 1: Design

This lesson plan was designed for a 50-minute session on the upper secondary level. It has four sections:

1. Introduction: Fakefinder
2. Brainstorming and discussion: characteristics of fake news
3. Theoretical input: article on AI and fake news
4. Exploring a new tool: generating fake posts on zeeob.com
5. Conclusion: multiple choice quiz

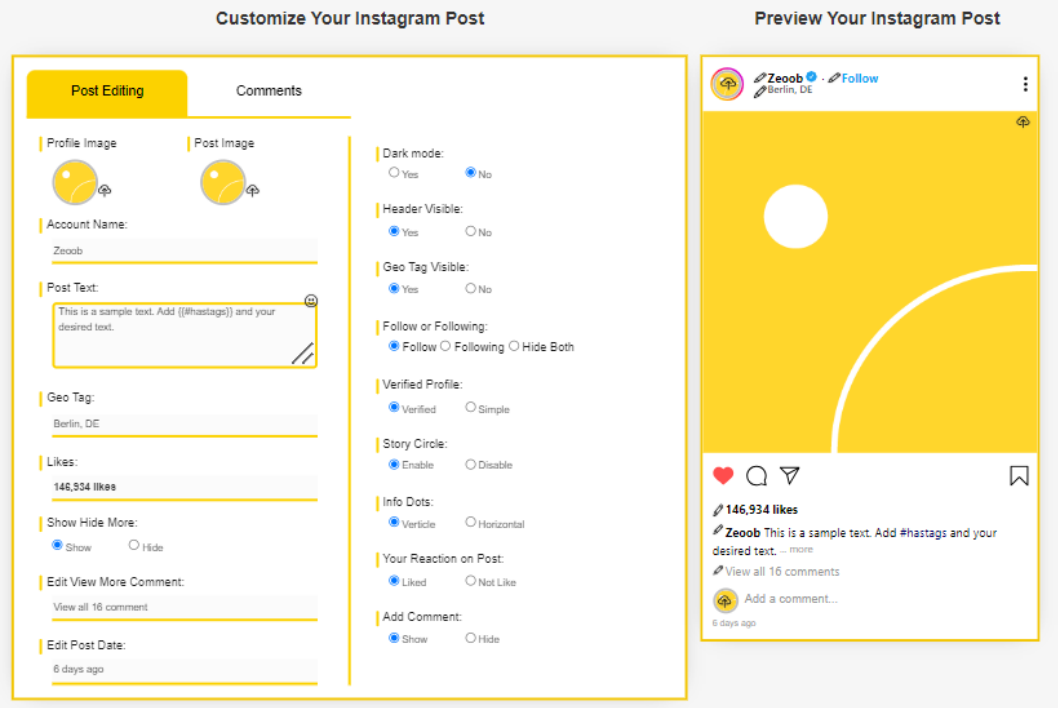

Figure 7: Zeeob post generator (https://zeoob.com/)

The FNP lesson opens with a dynamic activity where students use the "Fakefinder" tool to differentiate between authentic and fake news reports. This exercise intends to spark curiosity and set the stage for the core topic.

Afterward, students analyze the characteristics of fake news, compiling their findings using "Mentimeter." The teacher adds to this list as needed and offers supplementary resources to deepen the discussion. Students are furthermore provided with and asked to read an article on the influence of AI on fake news and posts, with its content being assessed in a Moodle quiz.

In the practical portion of the lesson, students are tasked with creating their own fake posts for various social media platforms, utilizing the "Zeeob" tool (see Figure 7) to demonstrate how easily media can be manipulated. They are asked to post their results on a prepared Padlet wall, displaying them to the class to collectively reflect on them. This hands-on activity demonstrates the deceptive techniques often employed in digital content.

To wrap up the session, a quiz is conducted to assess how well students have absorbed the material, ensuring key concepts are understood and retained.

5.3. Iterative cycles: Evaluation and Reflection

In the evaluation and reflection phase of design-based research, teaching materials undergo systematic investigation, with the aim of evaluating the intervention's effectiveness to ultimately draw conclusions for theory. This process unfolds within a structured cycle including three key phases (see Figure 8): *planning* (defining goals and methods), *fieldwork* (collecting data from participants), and *meaning making* (analyzing data and reporting findings) (McKenney & Reeves, 2019, p. 161).

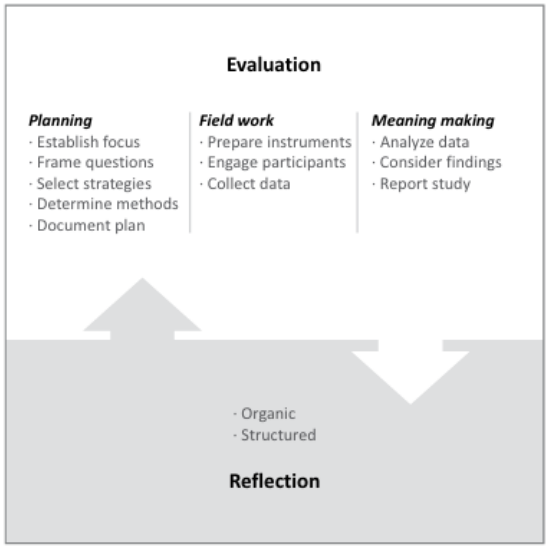

Figure 8: Main processes within the evaluation and reflection phase (McKenney & Reeves, 2019, p. 162)

In this context, evaluation involves gathering data to understand interventions, whether planned (designs) or created (prototypes). Reflection focuses on analyzing findings to refine ideas, improve designs, or enhance solutions. This phase clarifies the intervention's purpose, implementation, and impact while simultaneously providing assessment of design practices (McKenney & Reeves, 2019, pp. 161-162). The following chapter is concerned with analyzing the iterative design cycles of the OER described earlier, examining their development, adjustment, and impact.

5.3.1. Autonomous vehicles

Prototype 1: Formative evaluation

Descriptive Analysis

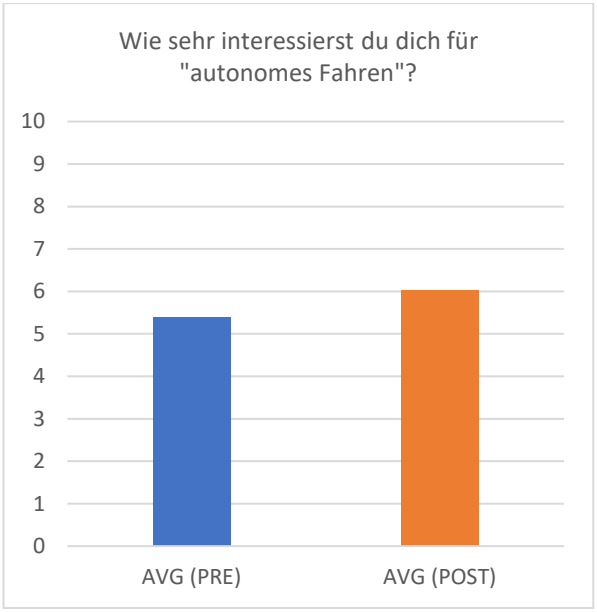

Figure 9: AV questionnaire item 1/4 (interest), 1st cycle

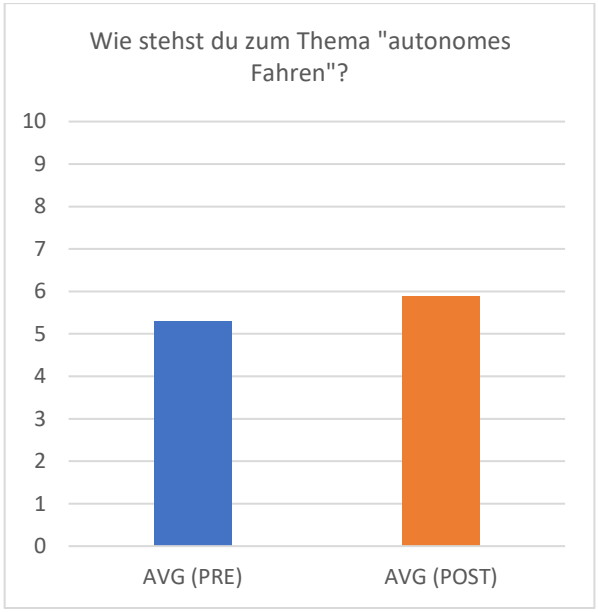

Figure 10: AV questionnaire item 3/6 (stance), 1st cycle

The two questions above can be translated as follows: "To what degree are you interested in the topic of 'autonomous vehicles'?" (Figure 9) and "What is your stance towards the topic of 'autonomous vehicles'?" (Figure 10). Both offered a scale from 0 to 10 to choose, while the first one defined 0 as "not interested at all" and 10 as "very interested" and the second one defined 0 as "I think AV have a negative impact on our society." and 10 as "I think AV have a positive impact on our society." Both questions were asked in the pre (blue column) and post (orange column) questionnaires. As shown in the graphs, there was a positive increase in interest and stance amongst the participants.

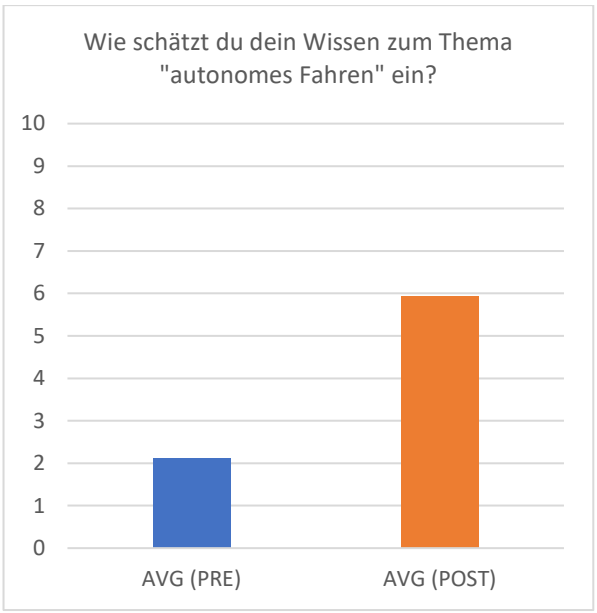

Figure 11: AV questionnaire item 2/5 (knowledge gain), 1st cycle

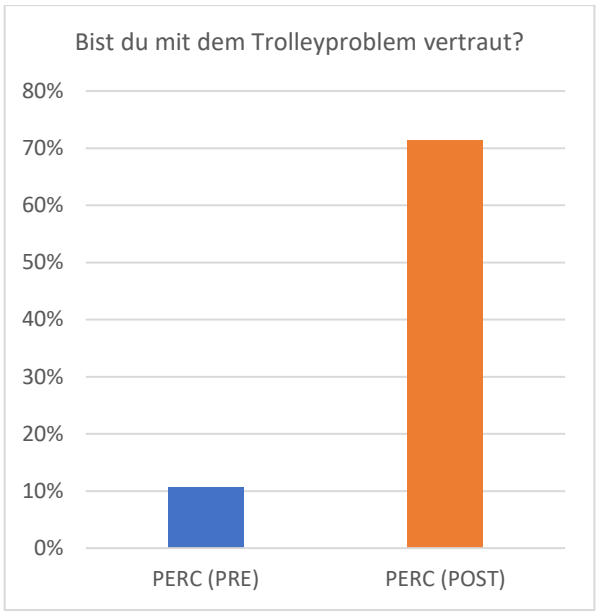

Figure 12: AV questionnaire item 7/8 (trolley problem), 1st cycle

The two graphs above refer to questions regarding the knowledge gain of the students throughout the lesson. The question on the left can be translated in "How would you evaluate your knowledge of the topic of 'autonomous vehicles'?" and offered a scale from 0 ("non-existent") to 10 ("very good: I know about the current developments in the field."). The graph on the right displays the percentage of participants who were familiar with the trolley problem, analyzing a content-related question. Again, the questions were asked in the pre (blue column) and post (orange column) questionnaires. Both graphs suggest a significant increase in the students' (perceived) knowledge gain.

Additional assessment

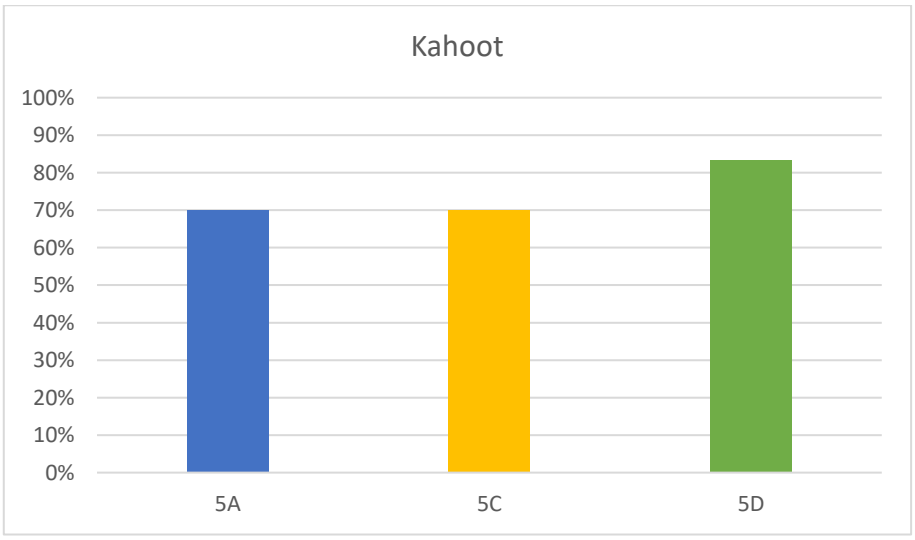

Figure 13: AV results of Kahoot quiz, 1st cycle

As can be seen from the table above, the students performed well in the Kahoot with group 5D demonstrating a high level of accuracy in their responses, correctly answering more than 80 percent of the questions. Group 5A and 5C too achieved more than two thirds of the correct answers. It must be considered that these results represent the students' performance as team players (two teams per group) rather than individuals. The dynamic amongst the group members can influence their results significantly. Leaving the success rate aside, the word *Kahoot* was mentioned in almost half of the questionnaires (13/28) when the students were asked what they liked most about the lesson. This shows the potential of gamification, not only serving as a covert assessment tool to evaluate student participation but also ensuring greater student engagement.

Qualitative analysis

Around half (14/28) of the participants would support the integration of the topic in school, out of which three mentioned autonomous vehicles' increased importance in the *future* as a reason. Over a third (10/28) of the students stated to be interested in the technology of autonomous vehicles; "how it works". In the post questionnaire, leading identified keywords to the questions "What comes to your mind first when you think about the lesson?" and "What was your favorite part of the lesson?" were *fun* (4/28) and *variety/interactivity* of exercises (3/28).

Reflection on first teaching cycle

As the instructions for the introduction in this lesson plan are quite vague, it turned out to be quite difficult to engage the students from the beginning, especially for a teacher lacking experience as well as the students being relatively young and not used to be confronted with ethical questions. This could be avoided by providing specific prompts or adjusting the introduction overall. What needs to be considered is that the students were provided with a short definition of autonomous vehicles preceding the first questionnaire in order to be able to complete it, which makes an additional discourse on it redundant.

Another issue that arose while teaching was the overuse of one tool, the Answergarden. Especially after the mentor teacher suggested adding one in the introduction to engage the students more, it became clear that the students were disinterested in doing more than two of the brainstorm activities. They either did not contribute or contributed inappropriate content, which is always a challenge using anonymous tools such as Answergarden. It appeared to be helpful to address the students' responsibility and maturity while using those tools or suggesting other ways to complete the activity if it does not work for them. Either way, the teaching practice showed that it would be

helpful to reduce the number of Answergardens and try to use different tools or methods to convey the content.

Figure 14: Example of Answergarden with inappropriate posts

Exploring the Moral Machine as well as the concluding Kahoot quiz seemed to be very popular and engaging for the students.

Assessment of quality criteria compliance in OER

Table 5 outlines the main categories of Zawacki-Richter & Mayrberger's framework for quality assurance of OER (2017), evaluates whether those were fulfilled in this lesson plan, and provides a corresponding justification.

Table 5: AV quality criteria

	Criteria	**Fulfilled**	**Justification**
Technological criteria	*Usability*	Yes	Answergarden & Moral Machine have an intuitive layout. Students have already known Kahoot. These tools encourage technological interactivity.

	Accessibility	Partly	Some of the activities rely on a stable internet connection (Answergarden, Moral Machine, Online articles, YouTube video). However, with some adjustment it could still work: The brainstorming activities may be switched to the board. The article (pdf) and some example scenarios (screenshots) from the Moral Machine could be made available offline and added to the materials. The websites can be accessed through different devices (computer, smartphone, tablet).
	Reusability	Yes	The order of the activities could be changed/adjusted. Activities could be easily added. The discussion questions/ brainstorming activities could be modified. It would also work well in a series of lessons concerning the topic of AI.
Pedagogical criteria	*Content*	Yes	The topic of autonomous vehicles is current and relevant for today's society. The sources for the lesson are accurate (levels of AV, video). The content is adequate and easily understandable for students. The materials can be reused.
	Learning Design	Partly	The lesson plan involves different media and tools but the use of the Answergarden tool may be reduced and exchanged with something else to increase student engagement even more. Collaboration with peers was encouraged through the group work activity. Learners were able to apply the newly acquired knowledge to real-life contexts (Moral Machine, effects on jobs).
	Assessment	Yes	The Kahoot quiz as well as the exchange after the group work provided opportunities for evaluation and feedback.
IPR criteria	*License*	Yes	No subscriptions or registrations were required for this lesson.

Prototype 2: Design

After completing the initial teaching cycle and reflecting on its effectiveness, the lesson plan was revised in order to enhance accessibility for teachers and engagement for students. The revised

plan begins with an exploratory approach by letting the students interact with the Moral Machine to immediately engage with the topic. After reflecting on the tool, the students are asked to get together in pairs and exchange their existing knowledge about autonomous driving. They are asked to share what they learned from their partner in the plenum. If necessary, the teacher may provide additional input on the ethical aspects of this technology, however, this should be done in a way that supports rather than overrides student discussions, avoiding a rigid lecture format.

Due to reasons described earlier, it was decided that the Answergarden activity on redundant jobs will remain in the lesson plan, while the two activities on advantages and disadvantages will be replaced with a guided debate between the two groups.

Additionally, students in the second cycle will be asked to complete the Kahoot quiz individually, rather than in their groups as originally planned. This adjustment is made to obtain a more accurate assessment of their knowledge gains. Although this change is due to scientific reasons rather than pedagogical ones, it provides valuable data to improve the lesson concept without negatively influencing the overall flow of the lesson.

Prototype 2/Final version: Formative Evaluation

Descriptive Analysis

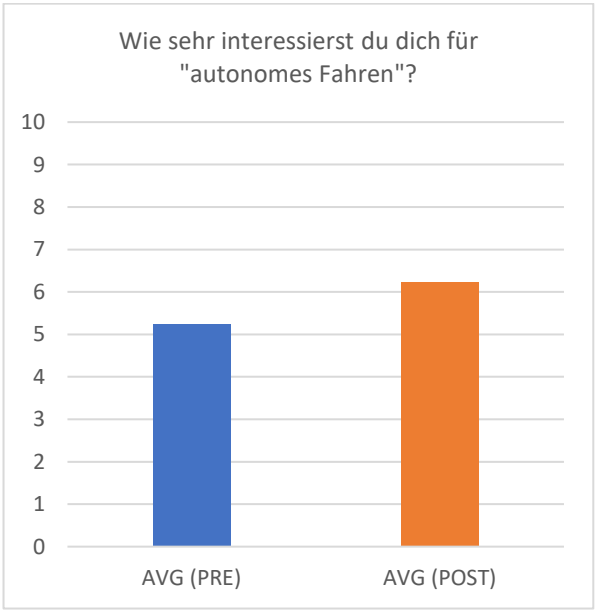

Figure 15: AV questionnaire item 1/4 (interest), 2nd cycle

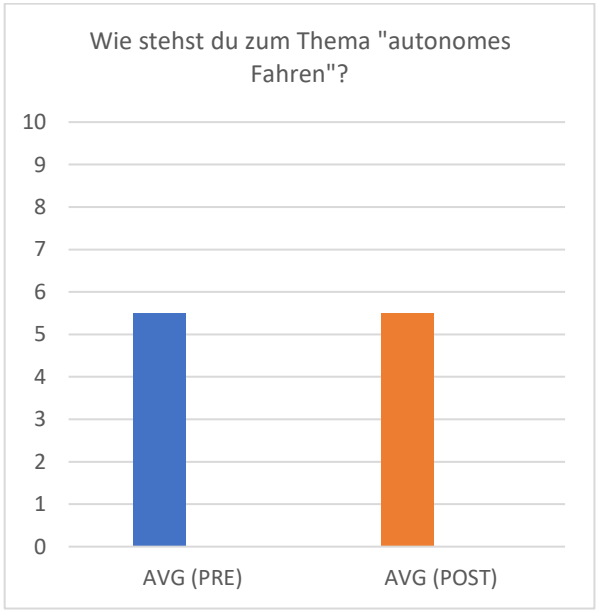

Figure 16: AV questionnaire item 3/6 (stance), 2nd cycle

During the second cycle, the same question of “To what degree are you interested in the topic of ‘autonomous vehicles’?” (Figure 15) was asked with a similar result to the first cycle; a slight

increase between pre and post survey. However, the question regarding stance (Figure 16) remained almost the same, while there was a slight decrease in one group and a slight increase in the other. The results, averaging around the value of 5, suggest that the students are not ready to take a clear position on the topic.

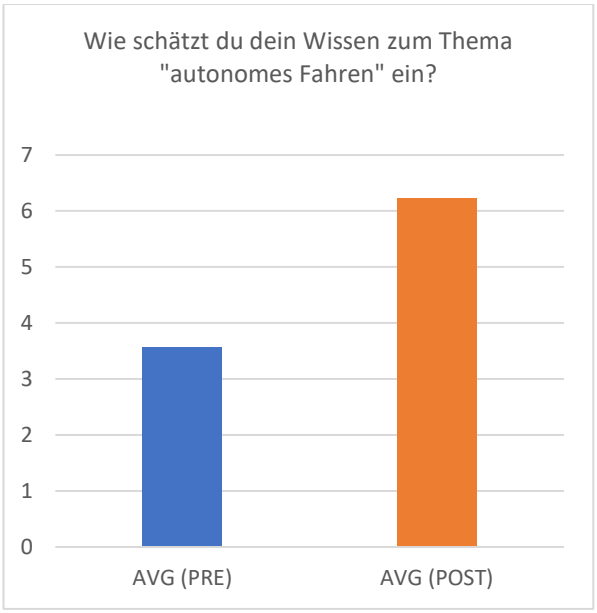

Figure 17: AV questionnaire item 2/5 (knowledge gain), 2nd cycle

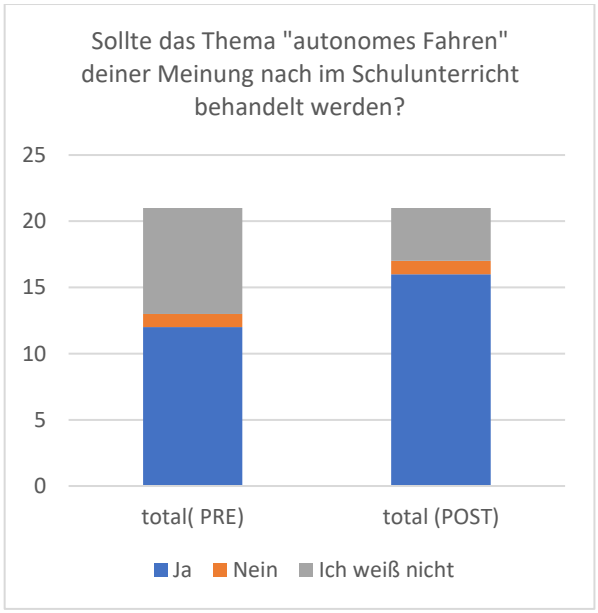

Figure 18: AV questionnaire item 4/7 (AV in school), 2nd cycle

Similarly to the first cycle, the data from the question "How would you evaluate your knowledge of the topic of 'autonomous vehicles'?" (Figure 17) shows a significant increase, underscoring the effectivity of the lesson. Moreover, the question "In your opinion, should the topic of 'autonomous vehicles' be integrated in school?" (Figure 18) was added in the post-questionnaire of the second cycle to compare results. As can be seen in the graph, the wish for learning more about this subject grew with the lesson.

Additional assessment

In the second cycle, the students were asked to participate in the Kahoot individually rather than in their teams from the preceding task. This produced a result of greater relevance regarding student performance. Group 5D_2 (blue column) still managed to reach a considerably high result, averaging with over 70% of correct answers. The results of group 5D_1 suggest a bigger impact of it being an individual effort rather than having the knowledge of all group members available during the quiz, as their mean score did not even reach the 60% mark. This could be explained with group 5D_2 being noticeably more (inter)active and therefore reaching a higher degree of collaboration during the group task.

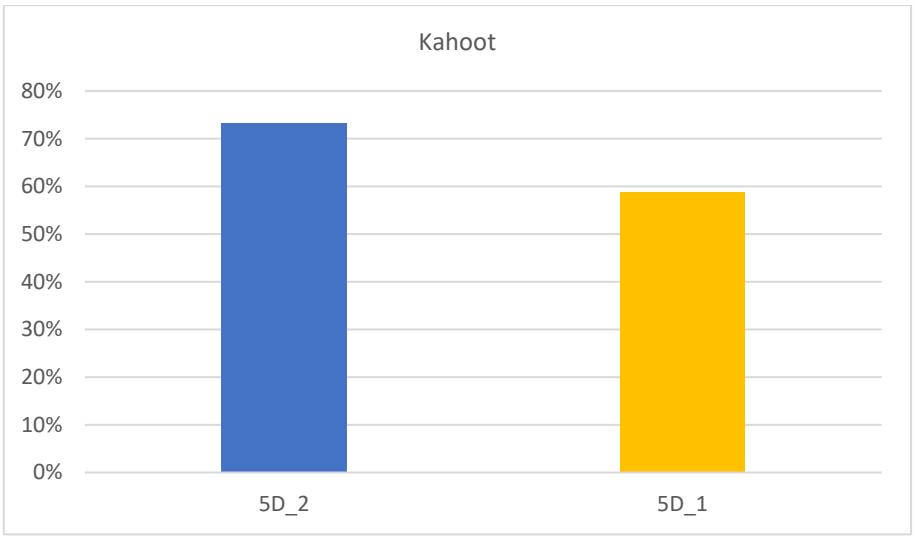

Figure 19: AV results of Kahoot quiz, 2nd cycle

Qualitative analysis

As previously discussed, the majority of participants support the idea of integrating the topic in school with an increasing number of advocates after the lesson. When asked why, the main idea located was its growing importance, identifying the keyword *future* (4/21 PRE, 6/21 POST) and phrases such as "it will be important later/someday" (2/21 PRE, 3/21 POST). The results suggest a slight increase in raising awareness about the topic and its increasing relevance for our society.

One significant change in the second cycle was the debate instead of the Answergarden. 4/21 students mentioned it as being the best part of the lesson, two of which even arguing that they would have liked to extend the debate/the debate was too short when asked what they did *not* like about the lesson. Two more responded that they liked the *group task* most, however, it is unclear if they were referring to the debate or expert groups about levels of AV. It is worth mentioning that those 6 were in the "more active" group and given clearer instructions for the debate creating better conditions overall.

Similarly to the first cycle, almost half of the students (10/21) named Kahoot as their favorite part of the lesson, once again showing the popularity of gamification in class.

Reflection on second teaching cycle

Exploring the moral machine worked well as an introduction, engaging the students right away. The "results" of the moral machine are a good starting point to interact with students and lead them to the topic. Questions such as "What was that like for you (making decisions on who to save)?" or "How did you do?" create a communicative atmosphere without any pressure to say the "right" thing. After that, the newly introduced pair work helped students to get more time to think about

the question and discuss it with their partner, making it overall easier to contribute later to the plenum. One of the biggest changes in the redesigned lesson plan was the debate. The students seemed to respond positively to the task, probably partly due to its competitive aspect. This can be even more highlighted by adding another gamification element and announcing a winner at the end of the debate. It became apparent that students need clear instructions for this setting in terms of structure. For instance, they need to be informed about arguments and rebuttals and how they interact with each other. Certain rules like not interrupting anybody or stating your personal opinion (if it opposes your assigned stance) should be discussed as well. Some students used inappropriate names in Kahoot, which can be irritating. Teachers could request students to use their real names and even use the results for assessment in a "normal" teaching setting.

5.3.2. Teaching and Learning with AI

Prototype 1: Formative evaluation

Descriptive Analysis

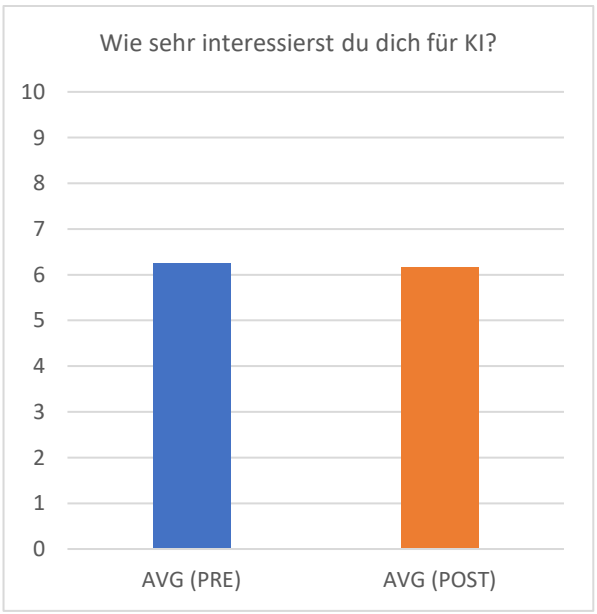

Figure 20: TL AI questionnaire item 1/4 (interest), 1st cycle

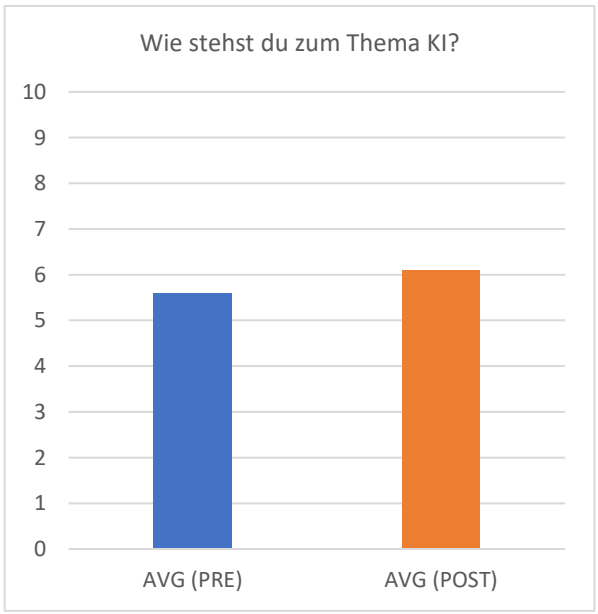

Figure 21: TL AI questionnaire item 3/6 (stance), 1st cycle

The two questions above can be translated as follows: "To what degree are you interested in AI?" (Figure 20) and "What is your stance towards the topic of AI?" (Figure 21). Both offered a scale from 0 to 10 to choose, while the first one defined 0 as "not interested at all" and 10 as "very interested" and the second one defined 0 as "I think AI has a negative impact on our society." and 10 as "I think AI has a positive impact on our society." Both questions were asked in the pre- (blue column) and post- (orange column) questionnaires. As seen in the left graph, the data showed no

significant changes between the pre- and post-questionnaires. However, there are slight differences between the three groups as one showed a slight increase, the other showed a slight decrease and yet another group's value stagnated. The graph on the right reveals a slight increase, suggesting a more positive opinion towards AI after the lesson.

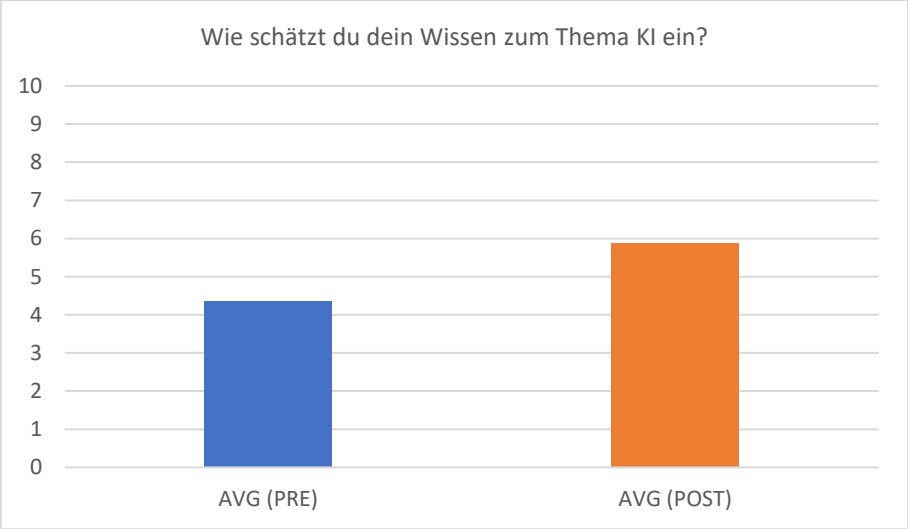

Figure 22: TL AI questionnaire item 2/5 (knowledge gain), 1st cycle

As was done in the first lesson, the students were asked regarding their perceived knowledge gain throughout the lesson. The question can be translated in "How would you evaluate your knowledge of the topic of AI?" (Figure 22) and offered a scale from 1 ("non-existent") to 10 ("very good: I know about the current developments in the field."). Again, the question was asked in the pre (blue column) and post (orange column) questionnaires. The data exhibits an increase in perceived knowledge gain.

Qualitative analysis

More than half (18/30) of the students surveyed supported the integration of AI as a topic in school, with five of them mentioning its relevance for the *future* in their reasoning. Another four of this group established that AI becomes increasingly important in our *society* or in *everyday life* as their justification. This shows that some students already have an awareness regarding the role of AI in our society.

When asked about their favorite part of the lesson, 6/30 students used the phrasing "alleine/selber ausprobieren" ("working alone/by myself"), indicating that they enjoy working independently. Another five answered with "Aufgaben" or "verwenden/arbeiten mit" ("exercises" or "using/working with") which can be interpreted similarly. This trend is certainly promising as

working independently is crucial for developing digital skills and adapting to the constant changes in the technological world.

Reflection on first teaching cycle

After teaching this lesson in three different classes, it became evident that the effectiveness of the brainstorming activity as an introduction depends strongly on group dynamics. At this age, students may feel shy or self-conscious in front of their peers, leading to limited participation in the brainstorming activity.

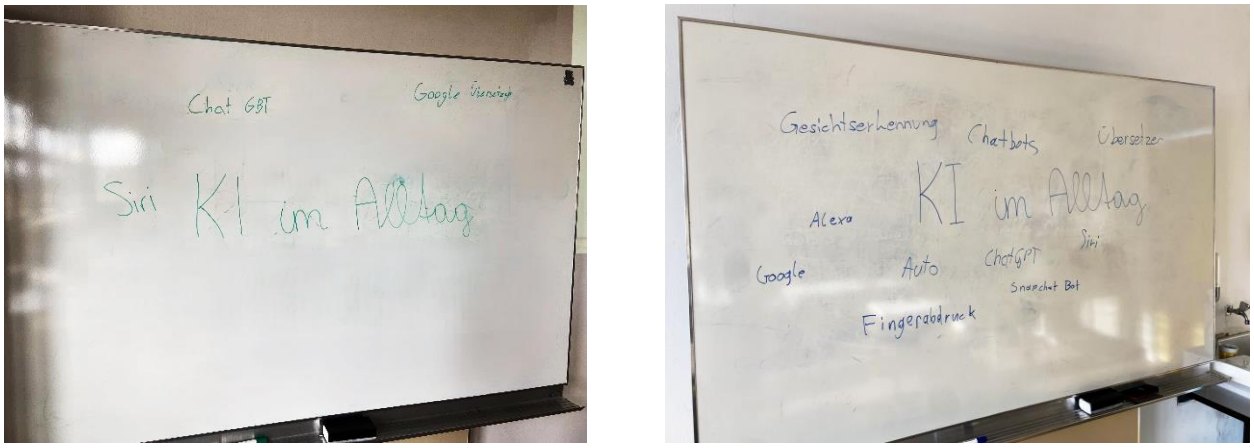

Figure 23: Comparison of brainstorming activity in two different groups

The theoretical input is appropriate for this age group as it provides a simplified definition of what AI is and how it "learns" without getting into technical details.

Although this lesson involves two brainstorming activities, they implemented different formats, ensuring a varied and engaging experience for the students. Compared to the previously introduced tool Answergarden, Mentimeter offers a more visually appealing and user-friendly experience, with automatic content updates. However, using Mentimeter does require the teacher to create an account, and the free version limits the number of participants per presentation, which is not necessary when using Answergarden.

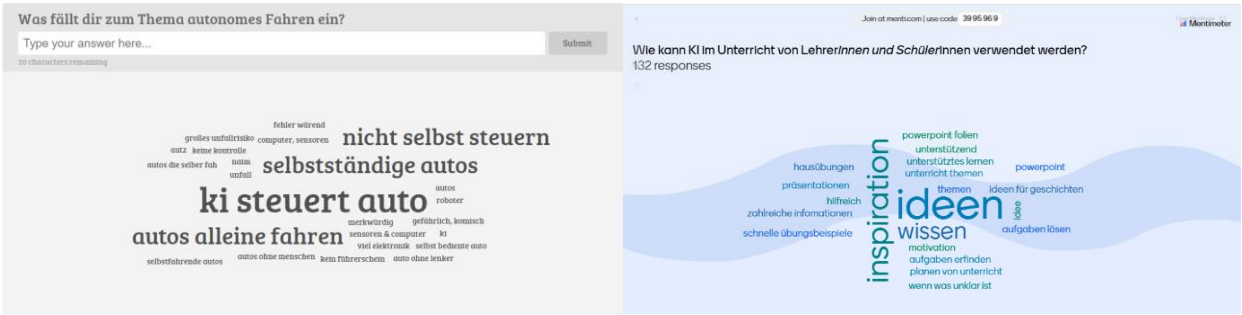

Figure 24: Visual comparison Answergarden (left) and Mentimeter (right)

Participants were asked to evaluate the tools used in each lesson on a scale from one to five stars. Since Answergarden and Mentimeter are two very similar tools, it seemed interesting to visualize students' opinions on them. As can be seen in the graphs below, there was a difference in the cycles. It is worth noting that the data from the first cycle considers four usages of the tool (2x Answergarden in AV and AI & Art, 2x Mentimeter in TL AI and FNP) whereas the data from the second cycle only considers the two usages in AV and TL AI, since the other lessons were not retried. However, it is noticeable that there was no significant difference in the evaluation of the tool in the first cycle, while Mentimeter was considerably more popular during the second cycle. Overall, both tools were positively reviewed in both cycles by the students with average scores lying in between 3,53 and 4,29.

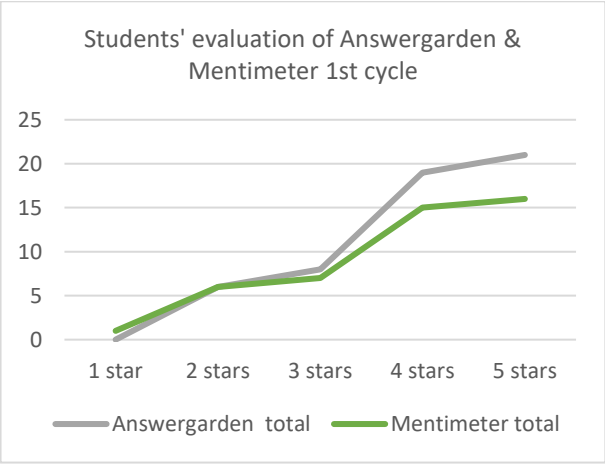

Figure 25: Students' evaluation of wordcloud tools, 1st cycle

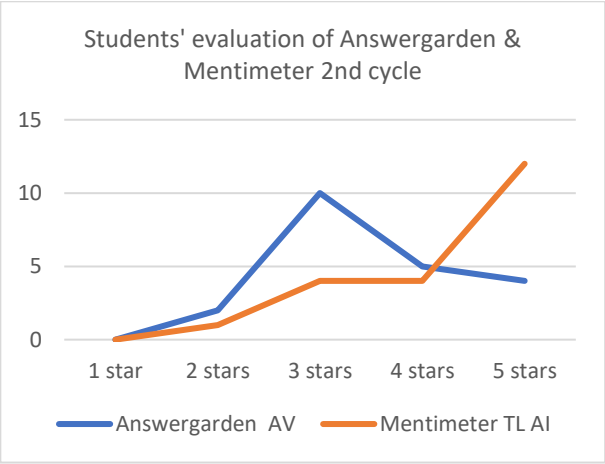

Figure 26: Students' evaluation of wordcloud tools, 2nd cycle

The results have shown that students like to be productive by testing new tools and working independently, which reflected in the practical part of this lesson. However, the prompt texts were quite complex and lengthy (designed to emphasize AI's ability to simplify/shorten content) which ended up being rather overwhelming than impressing.

As with other mentioned anonymous tools, there were also some inappropriate contributions on the Padlet which depend on group dynamics but need to be considered beforehand. There were several complaints about such contributions in the responses of the post-questionnaires which showed that they were not only irritating for the teacher but also for some students. Additionally, there might be repetition in the postings which is not very helpful.

For the concluding discussion, the lesson plan offers several options on its structure. It became apparent that the tested age group requires clear guidance and tasks to be part of the conversation.

Assessment of quality criteria compliance in OER

Table 6 outlines the main categories of Zawacki-Richter & Mayrberger's framework for quality assurance of OER (2017), evaluates whether those were fulfilled in this lesson plan, and provides a corresponding justification.

Table 6: TL AI quality criteria

	Criteria	**Fulfilled**	**Justification**
Technological criteria	*Usability*	Yes	Chat GPT, Mentimeter, DeepL, Padlet are user-friendly and/or already known by the students. These tools encourage technological interactivity.
	Accessibility	Partly	The tools and websites can be accessed through different devices (tablet, smartphone, computer). However, the activities mainly rely on a stable internet connection. The brainstorming and critical discussion could be moved to the board/plenum but without the input and results from the tools, extra material would be necessary.
	Reusability	Yes	The order of the activities could be changed/adjusted. Activities and tools could be easily added. The discussion questions/ brainstorming activities could be modified. It would work well as an introductory lesson in a series of lessons concerning the topic of AI.
Pedagogical criteria	*Content*	Yes	The topic of AI, especially in the form of chatbots, is a very current and relevant topic as the number of people using them is constantly rising. The content is accurate (machine learning, definition of AI) and it was adequately presented (context: school) and intelligible for students. The lesson plan can be reused in different contexts.

	Learning Design	Yes	This lesson plan offers a variety of different tools and methods. There is a possibility to work in pairs for the practical part to encourage collaboration. Students can apply their knowledge in real-life contexts (discussion about the use of AI in everyday life and school).
	Assessment	No	There is no opportunity for evaluation and feedback.
IPR criteria	*License*	Partly	Although there is a free and open (yet restricted) version of Chat GPT now, registration was required when the study was conducted. Also, Padlet and Mentimeter require registration, and the free version only allows a limited number of Padlet walls/polls.

Prototype 2/Final version: Design

Although a significant portion of the lesson was focused on practical work, which is generally motivating and fosters students' independence, there is room to adopt a more student-centered approach. The sample texts were (intentionally) chosen to be quite long and complex. In the second cycle, the teacher will invite the students (perhaps in a prior lesson) to bring their own materials and media that they need assistance with. This emphasizes the usefulness of these tools in real-life contexts.

The translating activity should not be restricted to DeepL. It presents an excellent opportunity for students to additionally use Google Translate and ChatGPT, allowing them to compare and even rank the effectiveness of these different tools.

Only using the Padlet for collecting advantages and disadvantages of text correction in ChatGPT seems like a waste given the tool's rich visual features and its design to simulate an analog pinboard. Therefore, the Padlet for this lesson was redesigned. Instead of focusing solely on the advantages and disadvantages of correcting texts in ChatGPT, the question was expanded to cover the use of AI in the classroom in general. Informational posts about AI, surveys on their favorite tools and reflection questions were added. This redesign (see Figure 27) made the Padlet a central resource for the entire lesson, helping facilitate discussions about the practical phase of the lesson by keeping all key information in one place; it also demonstrated the tool's potential for future project work.

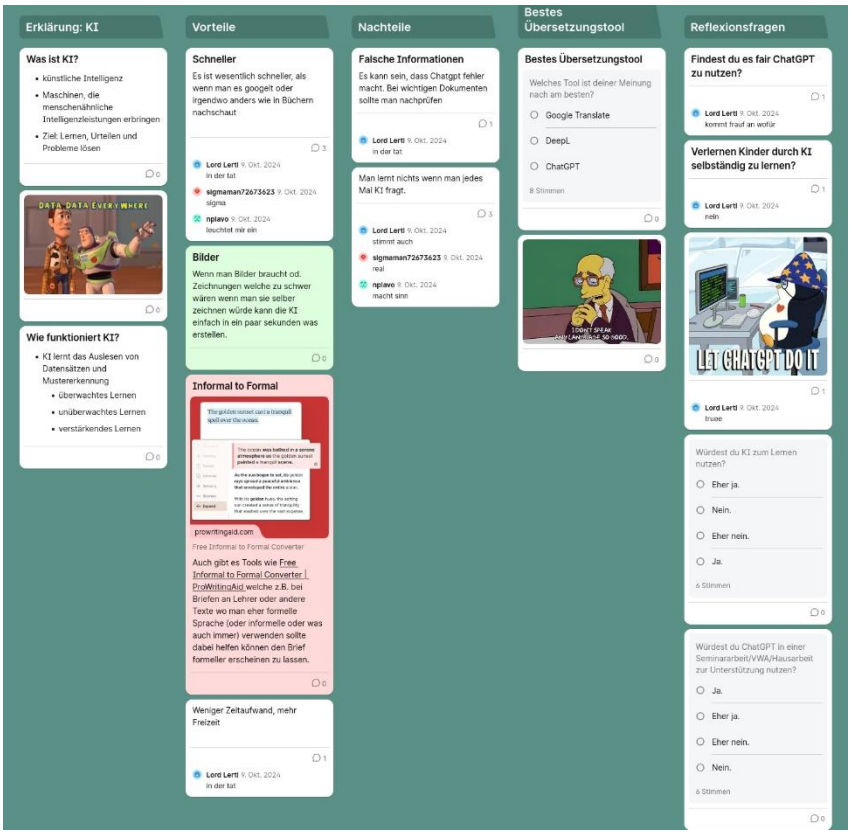

Figure 27: Redesigned Padlet wall

Prototype 2: Formative Evaluation

Descriptive Analysis

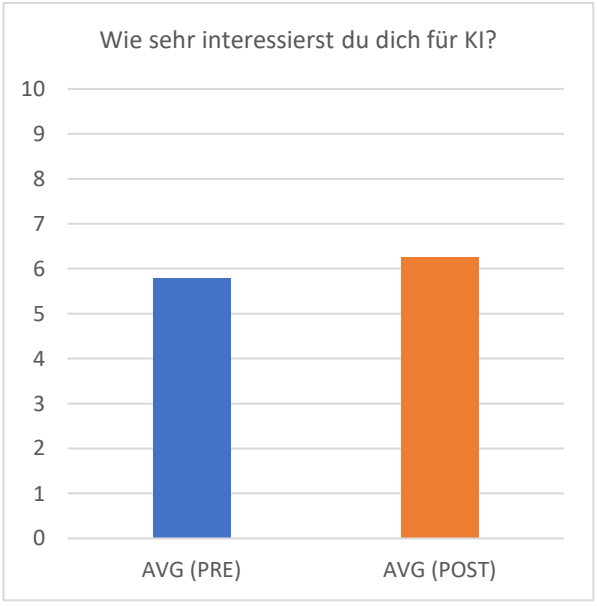

Figure 28: TL AI questionnaire item 1/4 (interest), 2nd cycle

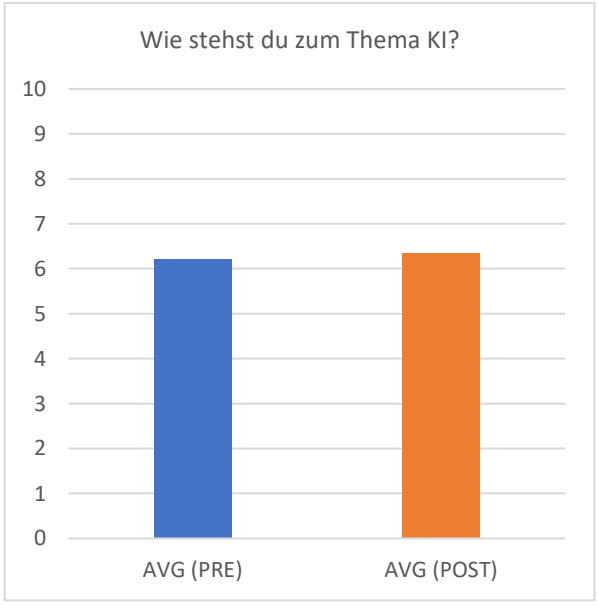

Figure 29: TL AI questionnaire item 3/6 (stance), 2nd cycle

During the second cycle, the same questions regarding interest (Figure 28) and stance (Figure 29) were asked again. Both display a slight increase in their average values, but no major differences to the first cycle.

Again, participants were asked how well they think their knowledge is regarding the topic of AI (Figure 30). The results show a noticeable increase in perceived knowledge gain between the pre- and post-survey.

In the second cycle, the question "In your opinion, should the topic of AI be integrated in school?" (Figure 31) was additionally included in the post-questionnaire to compare results. As can be seen in the graph, the number of students supporting the integration of the topic in class was already high before the lesson, increasing even more afterwards.

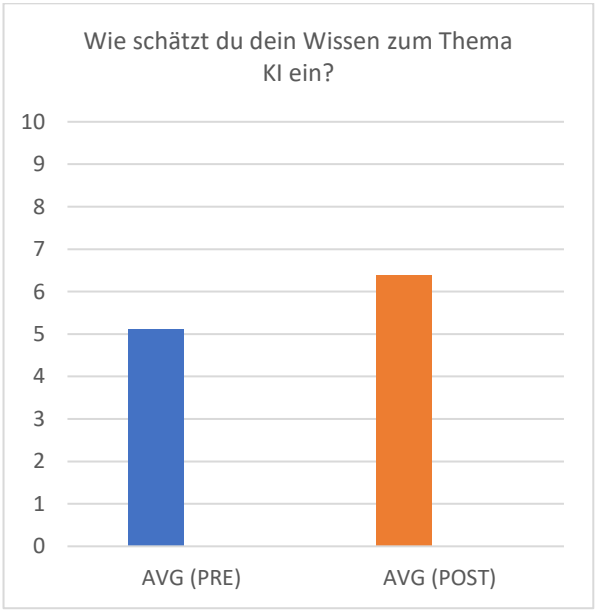

Figure 30: TL AI questionnaire item 2/5 (knowledge gain), 2nd cycle

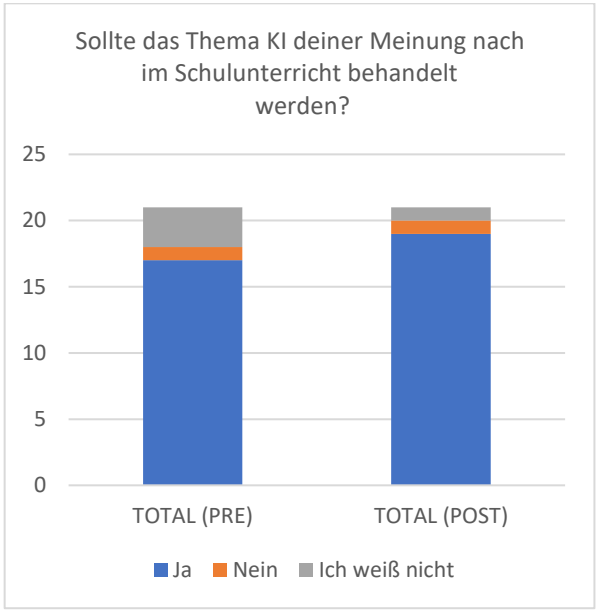

Figure 31: TL AI questionnaire item 4/7 (AI in school), 2nd cycle

Qualitative Analysis

When asked why AI should be integrated in school five students out of 21 mentioned AI's importance in the *future*, while another five noted that it is important to know *how to use* this technology responsibly and know about the dangers. Three students mentioned *Padlet* when asked about their favorite part of the lesson, suggesting its redesign was successful as well as highlighting the tool's potential. The inclusion of the Padlet throughout the whole lesson might have made it more memorable for students as well, giving them the chance to reuse it for their own purposes.

Reflection on second teaching cycle

The most significant insight gained from teaching this lesson a second time was the change in students' skills and knowledge of ChatGPT. During the first cycle, most students had to set up an account and never used the tool before, while several students of the second cycle reported that ChatGPT replaces search engines such as Google for them using it for any issues or questions they might have. This resonated in the fact that there was existing knowledge regarding the tool and its purposes. For this reason, a shift of the lesson's focus from the possibilities of usage towards the responsible use of ChatGPT might be helpful. This finding yet again shows how rapid developments in technology concern computer science education and call for constant adjusting and reviewing teaching materials.

5.3.3. AI and Art

Prototype 1: Formative evaluation

Descriptive analysis

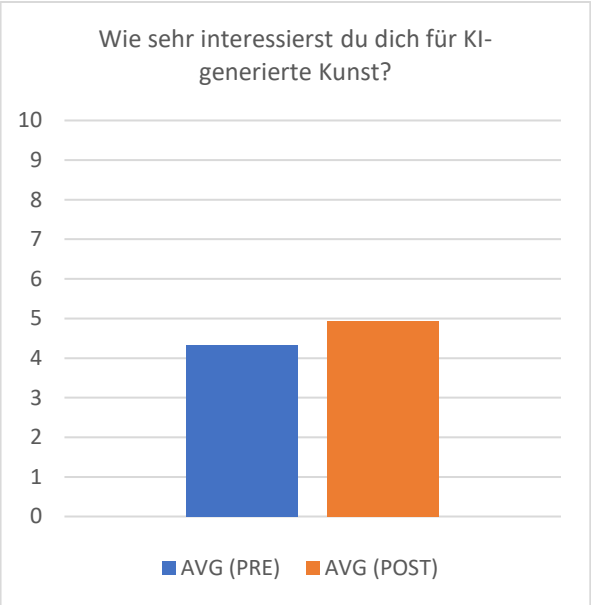

Figure 32: AI & A questionnaire item 1/4 (interest)

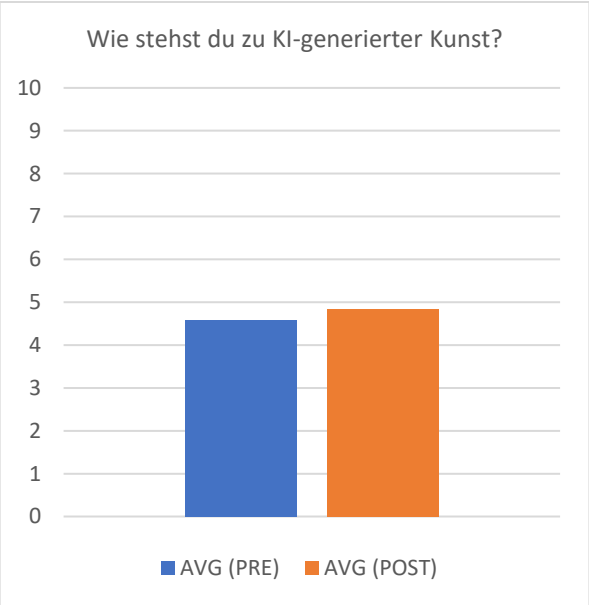

Figure 33: AI & A questionnaire item 3/6 (stance)

The two questions above can be translated as follows: "To what degree are you interested in AI-generated art?" (left) and "What is your stance towards the AI-generated art?" (right). Both offered a scale from 0 to 10 to choose, while the first one defined 0 as "not interested at all" and 10 as "very interested" and the second one defined 0 as "I think AI-generated art has a negative impact on our society." and 10 as "I think AI-generated art has a positive impact on our society." Both questions were asked in the pre- (blue column) and post- (orange column) questionnaires. The data

displays a slight increase in average interest and stance. However, there was a decrease in interest amongst the second group. It is important to know that only the data of six participants of this particular group was considered since some people were missing that day and another two did not finish the second questionnaire. The results, averaging around the value of five, suggest that the students are not ready to take a clear position on the topic.

Again, the students were asked regarding their perceived knowledge gain throughout the lesson. The question on the next chart can be translated in "How would you evaluate your knowledge regarding AI-generated art?" (Figure 34) and offered a scale from 0 ("non-existent") to 10 ("very good: I know about the current developments in the field."). Again, the question was asked in the pre (blue column) and post (orange column) questionnaires. The data exhibits an increase in perceived knowledge gain.

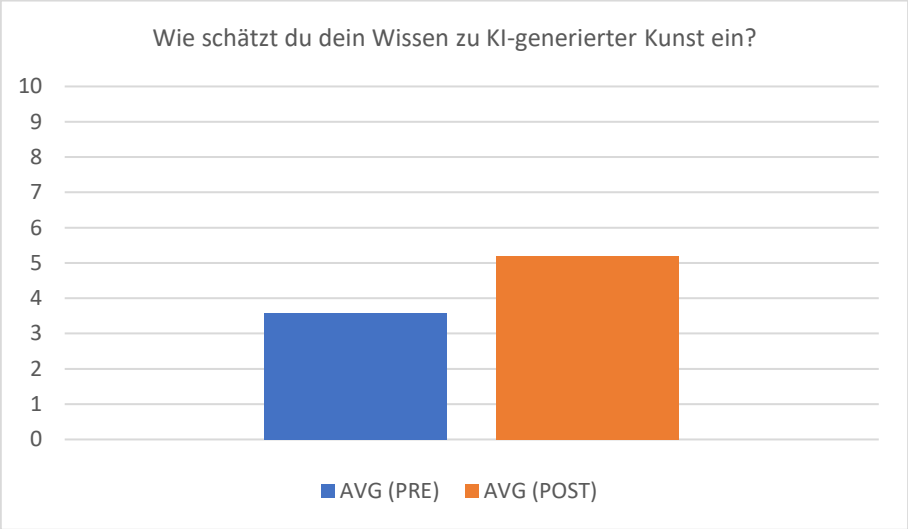

Figure 34: AI & A questionnaire item 2/5 (knowledge gain)

Qualitative analysis

More than half of the students questioned (14/26) did not give a definitive answer when asked whether AI & Art should be taught in school. Of the seven students, who believe the topic should be integrated, three mentioned its relevance for the *future* in their reasoning. The five students, who were opposed to an integration of the topic, argued that it is either unimportant or that there are more important subjects to teach.

Once again, six out of 26 students mentioned the words "eigene/selber" (*on my own/myself*) when asked what they liked most on the lesson or what first comes to their mind when thinking about the lesson, indicating they liked working independently. Ten others did not use those exact words but mentioned that their favorite or most memorable part of the lesson was *generating AI art*. As

previously mentioned, individual work as well as explorative learning approaches have the potential to motivate students to develop important skills for navigating the digital world, which is reflected in these findings.

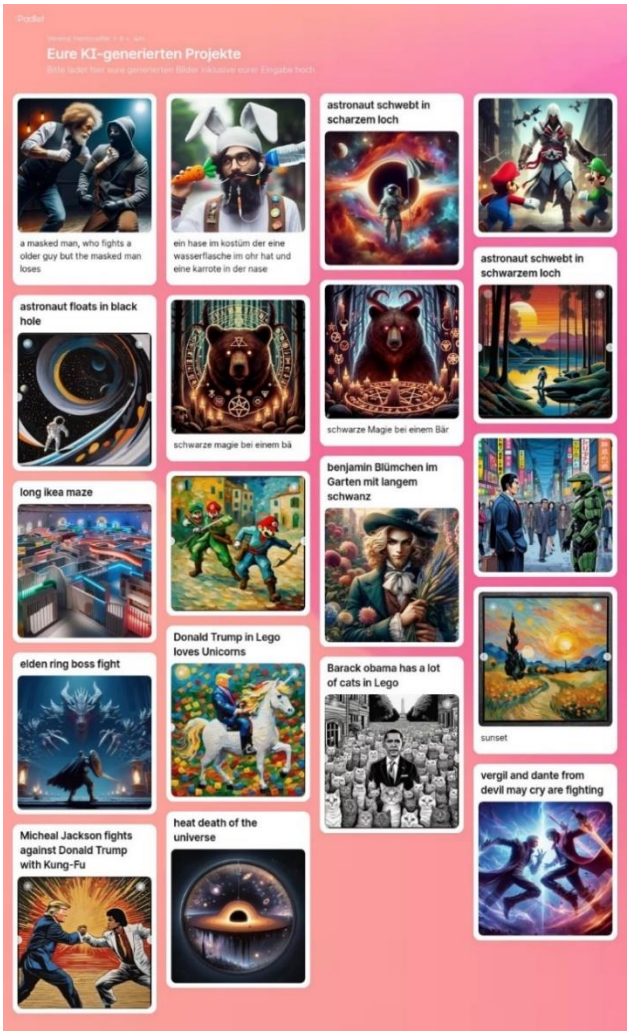

Figure 35: students' AI-generated creations on Padlet

When asked about the shortcomings of the lesson, four participants mentioned the philosophical text. Considering that this lesson was designed for 7th and 8th grade, it was no surprise that 5th graders struggled with the material. Additionally, two students would have preferred a topic other than AI, possibly as a result of this being the third lesson in the cycle.

Reflection on first teaching cycle

One consideration for the practical section is that the Bing Image Creator requires an account linked to a personal email address, which may raise concerns about data security.

During the lesson, the importance of clear and detailed prompting became apparent, as many students provided vague and brief prompts. While this resulted in some amusing outcomes, the purpose of the tool is not to guess what users want but respond accurately to well-defined inputs.

Although Answergarden offers the convenience of generating word clouds for free and without requiring an account, one drawback is that it does not automatically refresh. This lesson featured two wordclouds—one for challenges and one for potentials of AI-generated art—requiring the teacher to constantly switch between them and manually refresh to maintain interactivity and display the comparison. This process proved to be quite inconvenient when using this tool.

Since this lesson was planned for 6th grade and above, the input text for the concluding discussion showed to be too complex for the age group it was tested on (5th grade). The students struggled to understand the text, making it difficult to engage in a meaningful discussion. Even for teachers, the text can be challenging to interpret, especially if they are not familiar with philosophical concepts.

Assessment of quality criteria compliance in OER

Table 7 outlines the main categories of Zawacki-Richter & Mayrberger's framework for quality assurance of OER (2017), evaluates whether those were fulfilled in this lesson plan, and provides a corresponding justification.

Table 7: AI & A quality criteria

	Criteria	**Fulfilled**	**Justification**
Technological criteria	*Usability*	Yes	Bing Image Creator, Answergarden, Padlet are user-friendly and/or already known by the students. These tools encourage technological interactivity.
	Accessibility	Partly	The tools and websites can be accessed through different devices (tablet, smartphone, computer), although a smartphone screen might be a little small to handle the Bing creator. Moreover, the activities mainly rely on a stable internet connection. The brainstorming and critical discussion could be moved to the board/plenum but without the input and results from the tools, extra material would be necessary.

	Reusability	Yes	The order of the activities could be changed/adjusted. Activities and tools could be easily added. The discussion questions/ brainstorming activities could be modified. It would work well in a series of lessons concerning the topic of AI.
Pedagogical criteria	*Content*	Partly	The topic of AI and its impact on fine arts is a very current and relevant topic. The content is accurate (article), but it was challenging for the students to comprehend (*intelligibility/adequacy*). The lesson plan can be reused in different contexts.
	Learning Design	Partly	This lesson plan includes different tools and methods. It does not include any pair or group work, but students were able to share their experiences in the plenum. Students can apply their knowledge in real-life contexts (rethinking their use of AI generative tools, being aware of copyright).
	Assessment	No	There is no opportunity for evaluation and feedback.
IPR criteria	*License*	Partly	Students have to create an account with a private email address to use the Bing Image Creator, which raises data security concerns. To avoid that, various other tools that are openly available may be used. Also, Padlet requires registration, and the free version only allows a limited number of Padlet walls.

Prototype 2: Design

There are numerous image-generating tools available that are free to use without requiring an account. Students should have the opportunity to choose from these tools and be encouraged to experiment with several of them, using the same prompts to compare their results. This approach introduces an additional layer of analysis, allowing students to critically evaluate the differences between the tools and how they interpret the same input.

To help students create effective prompts, guidelines outlining key rules for successful prompting should be uploaded on the respective learning management system. This resource will assist them in improving their interaction with AI tools and producing more accurate results.

Instead of engaging in a philosophical discussion, students may be allowed to use ChatGPT to summarize and simplify the given text. This not only makes the material accessible but also provides students with an opportunity to apply the knowledge they gained in the previous lesson on "Teaching and Learning with AI". By doing so, they can deepen their understanding of AI tools while enhancing their comprehension of complex texts.

5.3.4. Fake News and Posts

Prototype 1: Formative evaluation

Descriptive analysis

The question below can be translated as follows: "To what degree are you interested in the topic of Fake News and Posts?". It offered a scale from 0 to 10 to choose, defining 0 as "not interested at all" and 10 as "very interested". The question was asked in the pre- (blue column) and post- (orange column) questionnaires. As seen in the graph, there was a positive increase in interest in the topic.

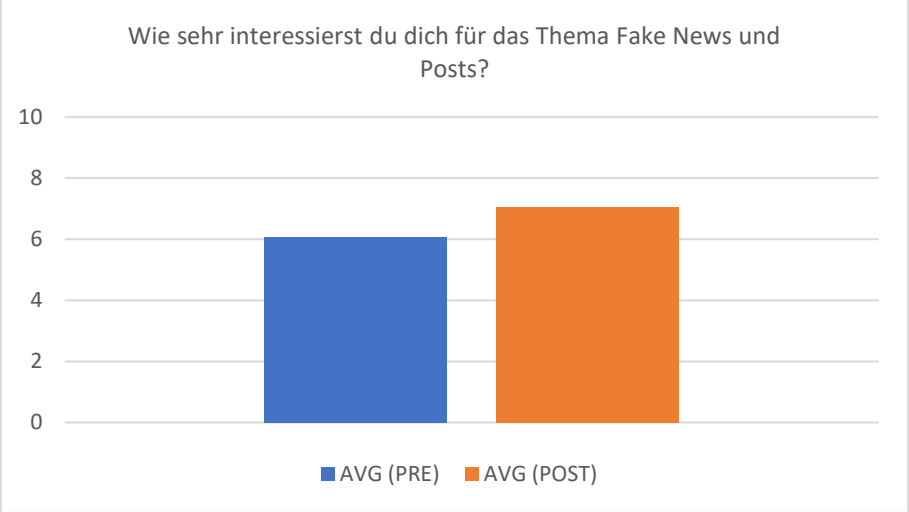

Figure 36: FNP questionnaire item 1/4 (interest)

As was done in the other lessons, the students were asked regarding their perceived knowledge gain throughout the lesson. The two questions below can be translated in “How would you evaluate your ability to recognize forged information?” (Figure 37) offering a scale from 0 (“very bad”) to 10 (“very good”) and “Do you think that you can differentiate Fake News from reliable news?” (Figure 38) providing the answers “Yes”/”No”/”I don’t know.” Again, both questions were asked in the pre (blue column) and post (orange column) questionnaires. The data exhibits a significant increase in perceived knowledge gain, suggesting that the students felt that they learned from the lesson.

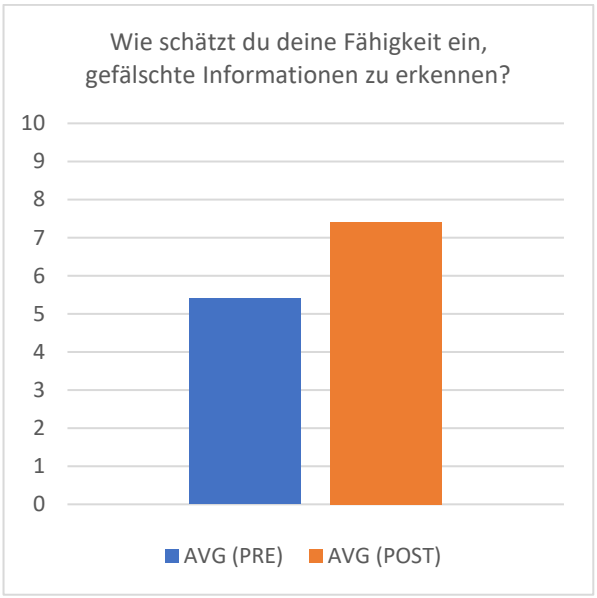

Figure 37: FNP questionnaire item 2/5 (identifying fake news)

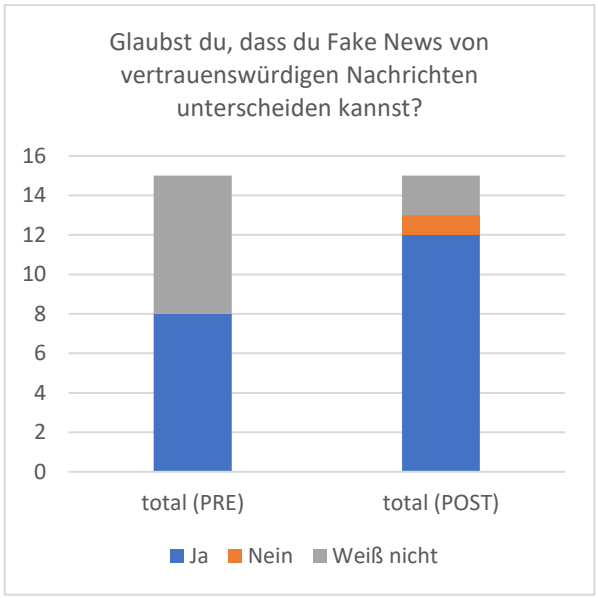

Figure 38: FNP questionnaire item 5/6 (differentiating fake news from reliable sources)

The question on Figure 39 can be translated into “Do you think that you or your opinion is influenced or changed by fake news?” with response options: “Yes/No/I don’t know.” It was asked in the pre- and post-questionnaire. The data reveals that, before the lesson, most students believed that Fake News influenced their opinions or were uncertain about their impact. However, after the lesson, the majority leaned towards negating the question. This shift may indicate that students have not fully understood the question initially which changed during the lesson. Another interpretation would be that they gained confidence through the activities, reevaluating their proneness to being influenced by such media.

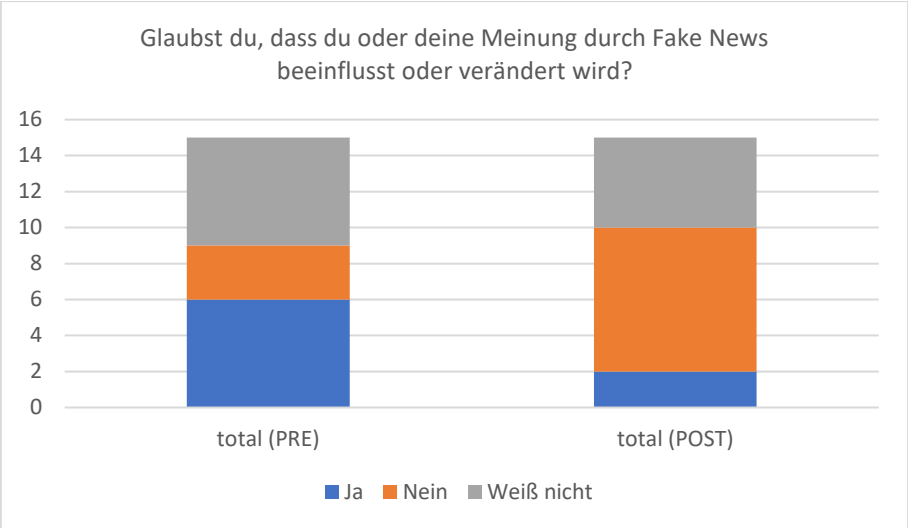

Figure 39: FNP questionnaire item 6/7 (influence of fake news)

Additional assessment: quiz

To conclude the lesson, the students completed a quiz on fake news. The quiz primarily involved multiple-choice questions based on the lesson's content, along with one open question regarding their personal experience, which can be translated to "Have you heard about (possibly absurd) fake news before? If yes, what was it, and did you realize that it was fake?". The graph below displays the average score reached by each group. Exclusively the multiple-choice questions are considered given the responses to the open question could not be measured quantitively. Out of six points to reach, both groups were able to achieve positive average scores with the second group performing slightly better. Overall, the results indicate the effectiveness of the tested lesson.

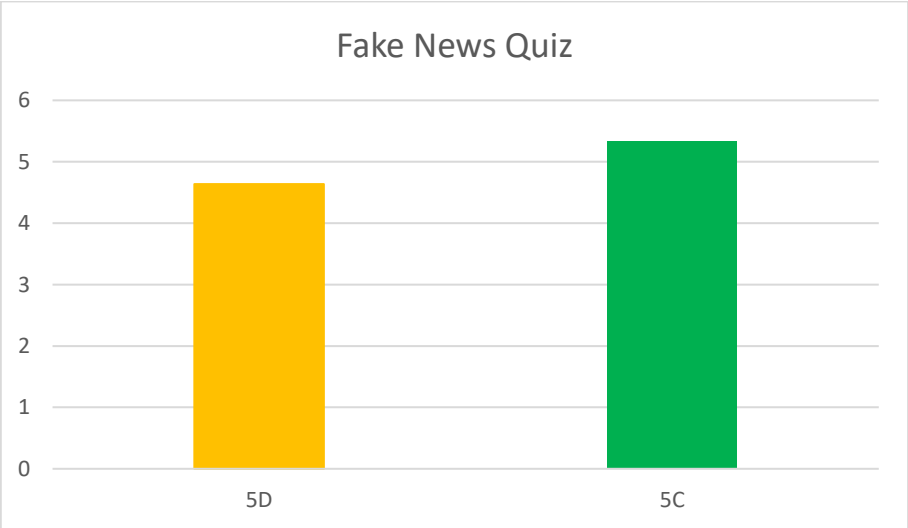

Figure 40: FNP quiz results

Qualitative analysis

More than two thirds (11/15) of the students mentioned that generating fake posts was their favorite or most memorable part of the lesson. Four out of those eleven used words such as “selber/eigenständig” (“by myself/independent”), highlighting their preference for activities that require autonomous working.

Reflection on first teaching cycle

Both groups showed active participation during this lesson. Since the students had already participated in three lessons related to AI and ethics, and the topic of fake news was not entirely new to them, there was no need for lengthy explanations or extensive input. The introduction featured an explorative approach, allowing students to navigate the Fakefinder website independently. This prepared them for the lesson’s content and helped them activate prior knowledge about the topic in question. Suitably, the follow-up activity on Mentimeter provided an overview of the students’ prior knowledge, giving the teacher an opportunity to address any missing or essential points. Following this, students received an article discussing AI’s influence on fake news, further drawing the line to the primary focus of AI and ethics. Unfortunately, the link to the Moodle quiz did not work and the questions were not included manually. During the practical part, it became clear once again that students enjoy experimenting with new tools and expressing their creativity. Since most of them frequently use social media apps featured in the exercise, the activity raised awareness of how easily fake posts can be created. This initiated discussion on the ethical implications of such technology. Finally, the general quiz at the end of the lesson served as an additional assessment.

Assessment of quality criteria compliance in OER

Table 8 outlines the main categories of Zawacki-Richter & Mayrberger’s framework for quality assurance of OER (2017), evaluates whether those were fulfilled in this lesson plan, and provides a corresponding justification.

Table 8: FNP quality criteria

	Criteria	Fulfilled	Justification
Technological criteria	*Usability*	Yes	Mentimeter, Padlet, and the various Webpages are intuitive and/or already known by the students. These tools encourage technological interactivity.
	Accessibility	Partly	The tools and websites can be accessed through different devices (tablet, smartphone, computer). However, the activities mainly rely on a stable internet connection. Offline materials of examples for fake news/posts could be prepared to be discussed. The brainstorming and critical discussion could be moved to the board/plenum but without the input and results from the tools, extra material would be necessary.
	Reusability	Partly	The order of the activities could be changed/adjusted. Activities and tools could be easily added. The discussion questions/ brainstorming activities could be modified. It would work well in a series of lessons concerning the topic of AI. The questions for the concluding quiz were included in written form to ensure reusability but the questions about the article are missing.
Pedagogical criteria	*Content*	Yes	The topic of fake news and posts is a very current and relevant topic, especially considering the rise of AI and generated images. The content is accurate (article), and it was adequately presented (context: social media) and intelligible for students. The lesson plan can be reused in different contexts.

	Learning Design	Partly	This lesson plan includes different tools and methods. It does not include any pair or group work, but students were able to share their experiences in the plenum. Students can apply their knowledge in real-life contexts (being critical on social media, checking sources).
	Assessment	Yes	A quiz at the end provides an opportunity for evaluation and feedback.
IPR criteria	*License*	Partly	Padlet and Mentimeter require registration, and the free version only allows a limited number of Padlet walls/polls.

Prototype 2: Design

To ensure genuine engagement with the article, formulating new quiz questions or incorporating another follow-up activity is essential. For the practical part, guidance questions for reflection could help structure students' thoughts. Another effective approach would be reflections in pairs or groups. This would not only encourage peer collaboration – an element currently missing – but also help students feel more confident when discussing and presenting their creations.

5.4. Theoretical understanding: Discussion

Reflection plays a crucial role in the research process, fostering the development of "new (theoretical) understanding" (McKenney & Reeves, 2014, p. 149). In this study, reflection was an organic and continuous process, occurring not only during and after the lessons but also while preparing for the second cycle, analyzing the questionnaires, and engaging with the literature. This approach allowed insights from the literature review and questionnaire data to inform ongoing reflections, shaping both the study's direction and its emerging findings. This section discusses the key insights gained through this reflective process and their implications for research.

An initial objective of this thesis was to explore existing literature on the creation of OER to determine the extent to which it provides guidance for their development. A review of relevant sources revealed key definitions, underlying principles, and quality criteria that can serve as valuable guidelines when designing teaching materials. Central to OER is the emphasis on free availability, adaptability, and reusability, ensuring that educational resources can be accessed, modified, and redistributed with ease. Additionally, collaboration among stakeholders plays a crucial

role in the sustainability and effectiveness of OER, as it fosters knowledge-sharing and continuous improvement (cf. UNESCO, 2002/2019; OECD, 2007; Zawacki-Richter & Mayrberger, 2017). According to these insights, the literature provides a strong foundation for the development of OER, highlighting both opportunities and challenges in their implementation.

The second research question focused on how students evaluated the teaching sequences in terms of interest, perceived knowledge gain, and tool use. Overall, student feedback was largely positive, with relatively high levels of engagement observed throughout the lessons. Many students expressed appreciation for the interactive and flexible nature of the materials, as well as the opportunity to work independently and creatively. However, some ethical concepts proved challenging to grasp, indicating a need for additional scaffolding or support in this area. Overall, students provided constructive feedback that contributed to refining the materials in the second cycle. These insights highlight the potential of iterative OER development based on learner responses.

The final research question study aimed to assess the original OER against the quality criteria identified by Zawacki-Richter & Mayrberger based on teacher's experience. The criteria of *Usability* and *Reusability* were found to be largely fulfilled, as all lesson plans incorporate various digital tools, methods, and activities allowing flexible adaptation and reuse in different teaching contexts. However, in terms of *accessibility*, all four lesson plans rely heavily on a stable internet connection, which poses potential limitations. To enhance accessibility, supplementary offline materials would be beneficial to reduce reliance on internet-based sources. Regarding *Content* quality, most of the materials may be considered relevant and appropriate for the intended learning objectives. The only exception was the AI & Art lesson, which was initially designed for an older audience, making certain aspects less suitable for the student group in this study. *Licensing* was only partly met as some digital tools used in the lessons – such as Padlet and Mentimeter – required registration, and their free versions had restrictions. Similarly, *Learning Design* emerged as an area for potential improvement, particularly in fostering collaboration and diversifying tool usage to enhance student engagement. Opportunities for *Assessment* were inconsistent across the lesson plans; while two of the teaching concepts integrated quizzes, the other two lacked any form of assessment.

Although the tested OER met several key quality criteria, the findings highlighted areas for further enhancement, particularly in accessibility, licensing flexibility, collaborative learning design, and assessment integration. These insights directly informed the refinement of the materials during the second research cycle, leading to targeted improvements that were implemented as part of this thesis.

5.4.1. Limitations

The findings of this study may be somewhat limited by the fact that it was conducted in a single school, at one educational level, and led by a single teacher (who was not fully trained). This inevitably limits the generalizability of the findings. Additionally, the number of students involved was relatively small, as computer science classes are usually taught in small groups due to the size of computer labs. In observational studies like this one, there is a potential for researcher bias, as the same individual is responsible for both leading the teaching process and collecting the data. To overcome these limitations, materials could be tested in different educational settings by a diverse range of teachers to assess their adaptability and effectiveness more broadly. An interdisciplinary approach could also be explored by integrating the lesson plans into other subjects, expanding their applicability beyond computer science. Another constraint was the limited number of design cycles conducted. Due to time restrictions, only two iterative cycles were completed for two of the concepts, while the remaining two concepts underwent just one cycle. Additional design iterations and a larger dataset would likely lead to further refinements and a more comprehensive evaluation of the materials.

5.4.2. Future work

Additional research is needed to ensure the materials' alignment with curriculum requirements and the evolving demand of future skills (McKeag 2023, p. 19). The DigComp framework (Vuorikari et al., 2022) could serve as a valuable foundation for assessing and enhancing the digital competencies embedded in these materials.

Given the relatively small sample size of this study, there is abundant room for further development through iterative revisions and broader testing of the materials. Expanding the research to include diverse educational settings, grade levels, and student demographics would provide deeper insights into the adaptability and scalability of the OER.

To facilitate ongoing refinement, implementing a structured quality assurance system could be beneficial. This could involve a collaborative network where educators share data, feedback, and redesign efforts to enhance the materials collectively. Establishing a platform widely recognized within the teaching community would provide a common space for educators to exchange best practices, discuss challenges, and co-develop high-quality OER.

5.4.3. Implications

One of the most striking findings of this thesis was the rapid shift in students' usage of AI chatbots, such as ChatGPT. During the first cycle, these tools were just beginning to gain widespread

popularity, and many students had not registered yet or actively used them. Approximately one year later by the second cycle, students had become highly familiar with AI chatbots, frequently incorporating them into their learning processes. Many even reported substituting search engines such as Google with AI-driven tools for information retrieval.

This shift significantly influenced how students interacted with the teaching materials, altering the classroom dynamics and the ways in which information was accessed and processed. The growing reliance on AI-powered tools is just one example of the rapidly evolving digital landscape which underscores the increasing need for Open Educational Resources (OER) that are adaptable and regularly updated to remain relevant. Educators must continuously revise and refine OER to ensure they reflect current technological advancements and integrate AI literacy as a core component of digital education. This highlights the broader implications of emerging technologies in education and the necessity of designing flexible, future-proof learning materials.

6. Conclusion

This study has provided valuable insights into the creation, adaptation, and evaluation of Open Educational Resources (OER). The approach of design-based research (DBR) proved to be highly effective, as its flexible nature allowed for continuous refinement of the lesson plans based on authentic classroom interactions and student feedback. The findings highlight the need for adaptable and regularly updated teaching materials, particularly in rapidly evolving fields like computer science. A key takeaway from this research is that the topic of AI and ethics does not solely feature technical topics but also requires the development of critical thinking, ethical reasoning, and reflective skills. Further studies could build upon this research by conducting long-term assessments of the materials and testing them across diverse educational contexts. Additionally, creating a collaborative space for educators to exchange experiences, share best practices, and co-develop OER could significantly contribute to the continuous improvement and broader adoption of high-quality, open-access teaching resources.

7. Reflection on the use of AI for this thesis

Beyond examining the integration of artificial intelligence in the classroom, this thesis also took advantage of AI tools to support its own development and completion. The tool of choice was ChatGPT – specifically the ChatGPT-4o model – which requires registration but is free of charge. Given the complexity and scale of a Master's thesis, maintaining coherence and flow can be challenging. ChatGPT proved to be of great assistance, particularly in restructuring sentences to

enhance clarity and cohesion. It was also especially helpful when introducing new sections or transitioning between paragraphs—often a difficult aspect of academic writing. Since prompts typically included some written content in my own words, instructions such as “Would you change anything in this sentence?”, “Can you enhance the structure of this sentence?” etc. were usually sufficient to receive satisfying responses. Another affordance of the tool is the facilitation of the literature research by summarizing lengthy or complex academic papers and making the selection of sources more efficient. Overall, ChatGPT significantly reduced the workload involved in writing this thesis, allowing for greater focus on the research itself. As an educator, it is essential to understand the tool’s capabilities through experiences and promote its responsible and critical use among students.

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AI tool used in this thesis

ChatGPT – 4o

Link: https://chatgpt.com/

For more information on the use of AI in this thesis, see Chapter 7.