Towards a Generative Artificial Intelligence Competence Framework for Schools

Lana Sattelmaier [1] and Jan M. Pawlowski [2]

[1,2] Ruhr West University of Applied Science, Bottrop, Germany
[1] lana.sattelmaier@hs-ruhrwest.de

Abstract. Artificial Intelligence will change the workplace in all sectors within a short period of time. One of the key questions is how we can prepare the next generation for the emerging challenges. Therefore, we have developed a competence framework for schools, focusing on teacher's kids in K12. The framework consists of multiple levels: basic competencies (e.g., computational thinking, data competencies), AI competencies (e.g., Machine Learning), and emerging competencies (e.g., prompting in Large Language Models). Our competence framework can serve as a starting point for curriculum design and competence standards. One of the key challenges will be the interrelation of those competencies, i.e., how will AI change basic competencies in the future.

Keywords: competence framework, competencies, skills, Generative Artificial Intelligence, Artificial Intelligence, K12, schools, educators.

1 Introduction

Artificial intelligence (AI) has a significant impact on society and industry. The increased use of AI in various fields requires a workforce with strong computational skills and the ability to work with AI. Especially the current hype of Generative Artificial Intelligence (GAI) has the potential to disrupt the job market and will lead to significant changes of competencies of the workforce. This also means that the educational sector has to include new competencies into their programs. Already now, AI is starting to provide new teaching and learning solutions. These solutions can be used for school tasks and have the potential to bring significant changes in the way education is delivered and received. However, AI in the classroom also raises important concerns, such as the potential for bias and the need to prepare teachers for this new kind of education.

In recent years, computer science education has rapidly expanded into K-12 curricula. This has allowed students to become creators of technology and has facilitated personal expression and creativity. However, there is still a lack of consideration for introducing AI to K-12 students.

Artificial intelligence has the potential to revolutionize education by providing new and advanced tools for learning and teaching. In the classroom setting, AI can offer students personalized learning experiences, automate repetitive tasks, and provide real-

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time feedback. However, the implementation of AI in education also poses significant challenges and limitations.

Some educators may perceive AI as a potential threat to their profession, but it can be viewed as a tool to aid them in their work. AI should be developed and utilized as a complement to, rather than a substitute for, human instructors. While AI may provide personalized learning and immediate feedback, it may not be able to replace the critical human interaction and emotional support necessary for student success. As a result, overreliance on AI-powered educational tools could have negative implications for student outcomes [1]. Therefore, the problem this paper addresses is to create a competence model for AI in K-12 education.

To address the problem statement, the following research question will be answered: "What are the key AI competencies that K-12 students and teachers need to develop to effectively use AI technology in education?"

The goal of this paper is to provide a competence model associated with AI in the school system. This model will focus on the impact of AI on 7th to 12th grade students. A systematic literature analysis was conducted and existing digital competence frameworks and other current models were examined to create a basic layout for the model.

2 AI Competence Frameworks

2.1 Defining Artificial Intelligence and Generative Artificial Intelligence

In the following, we briefly clarify our understanding of Artificial Intelligence. We also outline why Generative Artificial Intelligence will have a strong influence on all aspects of (work) life.

Artificial Intelligence (AI) is a broad and dynamic domain of computer science that aims to develop machines or systems that can exhibit human-like intelligence in performing various tasks. A clear and precise definition of AI is essential for exploring its diverse and complex connections with education. However, defining AI is not a simple task, as it is constantly evolving and expanding with the rapid progress of technology. Some of the factors that have contributed to the recent growth and popularity of AI are the availability of large-scale data sets, also known as big data, the increased accessibility and affordability of computing power, and the significant advances in the field of machine learning [2].

AI in general refers to the ability of a computer or machine to perform tasks that would normally require human intelligence, such as learning, problem solving, decision making, and language understanding. It is also briefly summarized as "thinking and acting humanly" [3].

In contrast, Generative AI is a branch of AI that aims to create new data or content from existing data or content, such as text, images, audio, video, code, or simulations. Lim et al. [4] state "*Generative AI can be defined as a technology that (i) leverages deep learning models to (ii) generate humanlike content (e.g., images, words) in response to (iii) complex and varied prompts (e.g., languages, instructions, questions)*." Generative AI can be used for various applications, such as entertainment, education, healthcare, design, and engineering. Generative AI can also enhance human creativity

and innovation by providing novel and diverse solutions to complex problems [5]. The main difference between classical AI and generative AI is that classical AI aims to mimic or surpass human intelligence in performing certain tasks (such as reasoning, planning, problem-solving, and decision-making), while generative AI aims to augment or enhance human creativity and innovation in creating new content. As there is consensus that GAI will disrupt work life [6], there are many opportunities and challenges for both organizations and individuals. Dwivedi et al [7] summarize the potentials of GAI as

- Creating new and diverse content that can enhance human creativity and innovation in various domains and industries, such as entertainment, education, healthcare, design, and engineering.
- Providing novel and effective solutions to complex and ill-defined problems that require exploration, experimentation, and discovery.
- Augmenting human capabilities and performance by providing assistance, feedback, inspiration, or collaboration.
- Enabling new forms of expression, communication, and interaction enriching human experiences and culture.

However, there is a variety of challenges, amongst them:

- Risk of misuse or misinformation, where generative AI can produce fake or misleading content that can harm individuals or society.
- Lack of transparency and explainability, where generative AI systems are difficult to understand or interpret by humans or other systems.
- Bias, where generative AI systems may reflect or amplify existing biases or errors in the data or the algorithms.
- Legal issues, where generative AI systems may pose challenges for the existing laws and regulations regarding data protection, intellectual property, and automated decision-making.
- Dependence on technology, where generative AI systems may reduce the human learning and development opportunities or cause disruptions in case of failures.
- Lack of originality, where generative AI systems may only produce incremental or derivative content that does not reflect human creativity or innovation.
- Effect of culture and personal values, where generative AI systems may encounter different levels of acceptance or resistance from different groups or individuals [7].

2.2 Digital and AI Competence Frameworks

As a starting point, we analyze existing approaches serving as a base for our competence framework. We follow the Ala Mutka's definition: "competence is an ability to use knowledge and skills with responsibility, autonomy and other appropriate attitudes to the context of work, leisure or learning."[8] Furthermore, digital competencies are operationalized describing knowledge, skills and attitudes [9]:

- Knowledge refers to the understanding of the concepts, principles, and facts related to the use of information and communication technologies (ICT).
- Skills refer to the ability to apply knowledge in practical situations and perform tasks using ICT.
- Attitudes refer to the values, beliefs, and behaviors that influence the way individuals use ICT [9].

After those definitions, we review different competence frameworks for basic, digital and AI competencies. Various frameworks, self-assessment tools and educational initiatives have emerged at both international and national levels [8].

A commonly referenced framework for digital competencies is the Digital Competence Framework for Citizens (DigComp) [11]. It is a set of digital competencies needed to navigate effectively in the digital world and has been developed by the European Commission. It aims to assist educators, policymakers, citizens, and employers in comprehending and evaluating digital competencies. The European Framework for Digital Competence of Educators (DigCompEdu) is an extension of the DigComp framework, specifically tailored for educators [9].

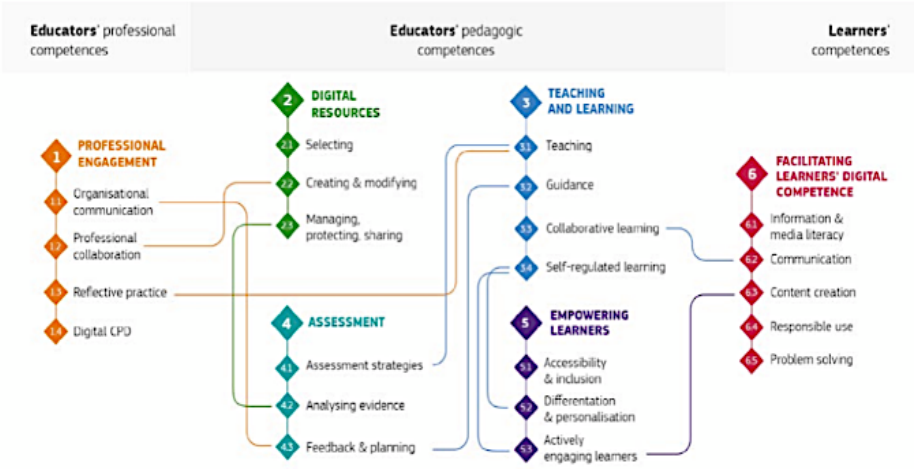

Fig. 1. DigCompEdu overview [9]

It outlines 22 digital competencies, categorized into six domains. When applied to the context of school education, the first domain (professional engagement) describes educators' skillful and appropriate use of technologies and digital education perspectives. These are used for effective communication and collaboration with colleagues, students, parents and other stakeholders. In addition, this domain emphasizes the importance of educators engaging in individual and collective self-reflection about their teaching practice. Domains 2 to 5, where the integration of technology is seamlessly woven into pedagogical practices, are central to the DigCompEdu framework. Domain 2 (Digital Resources) focuses on the curation, creation, modification and management of digital educational materials. This includes the protection of personal data in

accordance with data protection regulations and the respect of copyright in the adaptation and distribution of digital resources. The third domain (Teaching and Learning) focuses on the strategic integration of digital technologies into teaching methodologies. Its main goal is to merge digital tools and techniques to facilitate collaborative and self-regulated learning approaches whilst putting emphasis on the guidance and support learners require on their self-directed educational journeys. Domain 4 (Assessment) focuses on the practical use of digital tools to assess student performance and learning needs. It requires a thorough examination of performance data and the provision of customized, timely feedback to learners. Domain 6 (Enabling Learners' Digital Competence) states that educators who are proficient in digital media should encourage their students to manage digital risks and to use technology responsibly. This includes fostering information and media literacy, integrating activities for digital problem-solving and content production, and utilizing digital tools for communication and teamwork. Each competence within the DigCompEdu framework is defined across six proficiency levels (ranging from A1 to C2) in a progressive sequence that mirrors the Common European Framework of Reference for Languages (CEFR) [12].

According to the framework, individuals at the Newcomer (A1) level recognize the potential of digital technologies to improve educational and professional practice. Those in the Explorer (A2) tier understand the capabilities of digital technologies and are committed to maximizing their effectiveness in educational and professional contexts. Moving to the Integrator (B1) level, individuals test digital technologies in various situations and successfully integrate them into their activities to match their goals. At the Expert (B2) level, individuals proficiently use a wide range of digital technologies to enhance their professional endeavors, displaying a poised and innovative approach. Those classified as Leaders (C1) demonstrate a systematic and comprehensive approach to advancing educational and professional practice through digital technologies, adeptly selecting the most appropriate digital strategy for any situation. Positioned at the Pioneer (C2) level, individuals confidently explore complex and pioneering digital technologies and may even develop innovative teaching methods. Leaders and Pioneers represent the highest levels of critical evaluation and development within current practice [13].

Upcoming digital innovation initiatives are likely to result in significant transformations. In such an environment, digital competencies will not only be mandatory aspects for educators, but they will also become the primary indicators of their teaching abilities [14].

As education develops in response to digital advancements, a new horizon is emerging: one defined by the integration of AI. While digital skills are essential for navigating the digital landscape, the infusion of AI technologies into educational contexts introduces a set of competencies that education, students, and stakeholders must cultivate [15]. This shift takes us beyond digitals skills and into the realm of AI skills in education. The combination of technological expertise and pedagogical insight leads to new teaching methods and the development of vital skills for the future [16].

3 Generative AI in Education

Generative AI has been studied for different perspectives and disciplines such as Higher Education [17] and schools [18]. Based on a literature review, [19] summarizes the main tasks which are supported by GAI in education:

- Supporting research,
- Producing exams on a specific topic,
- Producing curricula and planning courses,
- Helping with assessments,
- Encouraging critical thinking,
- Summarizing large texts. [19]

Moreover, different types of content can be generated. More precisely, content can be identified (e.g. language / speech / object recognition), modified (e.g. image improvement, translation), transformed (e.g. text to image / video). Therefore, different types of content can be generated and manipulated [20], text, 2/3D images, videos, often using chatbot such as ChatGPT.

This leads to several opportunities such as providing personalized learning experience, providing writing assistance, supporting (language) learning or producing and translating code [19].

However, there are also several concerns and problems such as plagiarism concerns, transparency, bias, hallucination, or privacy concerns [19]. Moreover, specific educational processes will change such as the production of learning materials, assessment formats as well as didactic settings.

There is no question that GAI will disrupt school education for both teachers and students. Thus, both teachers and students will need to acquire competencies on a responsible, transparent and inclusive use of GAI.

4 Developing a Generative Artificial Intelligence Competence Framework

4.1 Methodology

There are a variety of potential methods for the development of competence frameworks. We modified the method of [22] using the following steps:

1. Literature review to identify existing competence frameworks.
2. Classification of competencies to define the different areas of competencies.
3. Identification of new competencies: As there are currently no comprehensive competence frameworks, we have identified challenges and opportunities of GAI to derive new and emerging competencies.
4. Mapping competence interrelations: This step is essential as the GAI competencies will affect and directly change different basic competencies (e.g. domain specific or digital competencies)

5. Prioritization of competencies to identify the most important competencies
6. Communication to involve further experts in the development of the competence framework
7. Expert validation to improve the framework

In this paper, we describe the first five steps of our overall methodology - as it is a position paper, we intend to stimulate the discussion and communicate our preliminary results.

4.2 Development of the GAI Competence Framework

The GAI competence framework integrates different levels of competencies which are highly interrelated:

- **Basic competencies** are necessary as a prerequisite to deal with the use of Artificial Intelligence.
- **Artificial Intelligence competencies** are specific competencies to understand, utilize and apply AI concepts, tools and technologies.
- **Emerging competencies** focus on Generative Artificial Intelligence as the main disruptive concept.

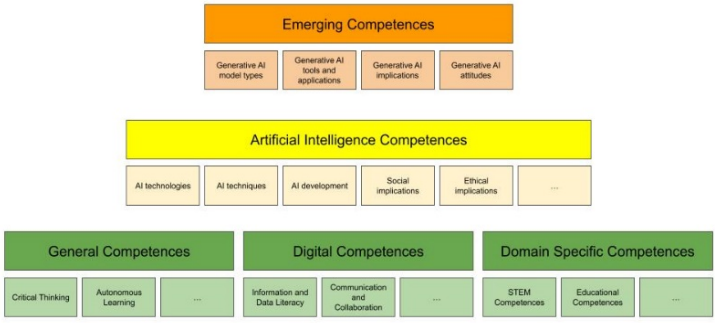

Fig. 2. GAI Competence Levels

The competence framework needs to create relations between the different levels. Each competence should be described by the following:

- **Competence description** describes the competence. A competence can consist of multiple knowledge objects, skills, and attitudes.
- **Competence statement** provides an operational statement which can be assessed.
- **Competence classification** describes the main competence subject (e.g. digital competence, AI technology, …).
- **Proficiency level** describes levels of mastering competencies. In our context the levels are differentiated by roles.
- **Role / level** describes either a role or a level / grade in school (e.g. teacher, student grade X)
- **Relation** links a competence to one or multiple competencies.

As mentioned above, relations are rather critical. Relations can be prerequisite or supporting competencies (e.g. the generic base competence of critical thinking is a prerequisite to critically analyze results of GAI tools). In our case, we recommend using a **relation "has influence on"**. By this relation, we can express that certain competencies might be substituted or changed through GAI competencies. As an example, the competence "designing lesson plan" could be partially substituted by a GAI tool. By introducing this relation, we know how competencies influence each other and might be changed in the future.

4.3 Basic Competencies

The level of basic competencies can be addressed by existing competence frameworks. Due to the complexity of these frameworks, we recommend using the following frameworks:

In previous research, we have developed a framework for generic and digital base competencies [22]. We use this framework describing knowledge, skills, and attitudes.

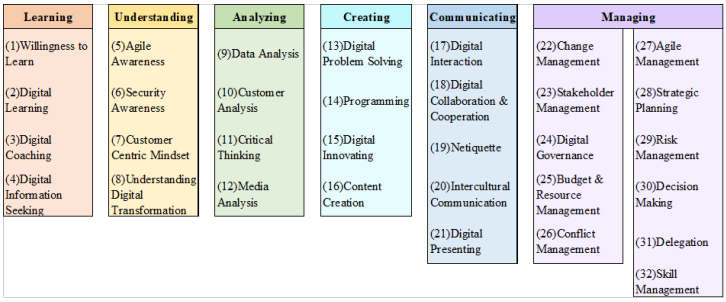

Fig. 3. Generic and digital base competencies [22]

Additionally, there are many basic competence frameworks for domain specific competencies - in the case of schools, we recommend utilizing the DigCompEdu framework [9] which provides a detailed description of base competencies for educators in the following categories:

- **Professional engagement:** competencies that enable educators to use digital technologies for their own professional development, communication, collaboration, and innovation.
- **Digital resources:** competencies that enable educators to select, create, manage, and share digital resources for teaching and learning.
- **Teaching and learning:** competencies that enable educators to enhance and transform their pedagogical approaches and strategies.
- **Assessment:** competencies that enable educators to design and implement assessment methods and tools that are valid, reliable, fair, and transparent.

- **Empowering learners:** competencies that enable educators to use digital technologies to empower learners to take ownership of their own learning processes and outcomes.
- **Facilitating learners' digital competence:** competencies that enable educators to use digital technologies to foster the development of learners' digital competence.

The basic level can and should of course also include other competence models, such as specific competence models for specific domains (such as engineering, design, craft sector etc). The main challenge is to relate those models to the upper levels, i.e., how might basic competencies be affected / changed by GAI competencies.

4.4 AI Competencies

To determine AI competencies, we analyzed ten existing frameworks [23, 24, 25, 26, 27, 28, 29, 30, 31, 32] and used the competencies and learning outcomes described in the "Mapping of Government-Endorsed K-12 AI Curricula" [23] as our primary point of reference. We have categorized the competencies as follows:

- **Algorithms - Computational Thinking:** competencies that enable proficiency in computational thinking, including a broad understanding of abstraction, decomposition, roles, and patterns.
- **Algorithms - Definitions and Applications:** competencies that enable to understand and use algorithmic concepts and their practical applications, enabling effective solutions for diverse challenges.
- **Algorithms - Components and Processes:** competencies that enable skillfulness in understanding the structure and process of an algorithm.
- **Programming - Programming Languages:** competencies that enable the skills of basic programming and to use different programming tools.
- **Programming - Representation and Simulations:** competencies that enable to represent real-world scenarios through code and reflecting on its limitations and possibilities.
- **Data Literacy:** competencies that enable the ability to comprehend, interpret, and extract insights from data, enhancing decision-making abilities across various domains.
- **AI Techniques - AI Definitions and Components:** competencies that enable profound understanding of Artificial Intelligence's foundations, including definitions and essential components.
- **AI Techniques - Data Use in AI:** competencies that enable a skillset to grasp how AI leverages data for learning, adaptation, and informed predictions.
- **AI Techniques - History:** competencies that enable the understanding of the historical progression of AI and offer perspectives on its origins, advancements, and development path.
- **AI Techniques - Understanding How AI Works:** competencies that enable to understand the mechanisms underlying AI technologies and demystify concepts such as machine learning, neural networks and GANs.

- **AI Technologies - Computer and Human Perception:** competencies that enable the comprehension of AI's ability to replicate human senses, such as vision and speech recognition, for the purpose of facilitating interaction and understanding.
- **AI Technologies - Understanding AI Technologies:** competencies that enable to comprehend a range of AI tools and applications, including natural language processing and robotics.
- **AI Development - Design Thinking:** competencies that enable the application of design thinking principles to AI development.
- **AI Development - Product Design:** competencies that enable integrating user needs with AI capabilities.
- **Applications of AI to Other Domains:** competencies that enable to identify AI use cases and its applications.
- **Ethics of AI - Ethical Terms, Definitions, and Examples:** competencies that enable to reflect on ethical concepts within the AI context, including terms like bias, fairness, and accountability through practical cases.
- **Ethics of AI - Access:** competencies that enable to understand the issues of access to technology.
- **Ethics of AI - Bias:** competencies that enable the explanation of how programmers' biases influence the fairness of AI rules, strategies to mitigate them, and identification of various bias types.
- **Ethics of AI - Intellectual Property:** competencies that enable to understand the challenges and ethical considerations regarding intellectual property rights in AI innovations.
- **Ethics of AI - Privacy and Security:** competencies that enable to comprehend the ethical aspects of data security and protection in AI implementations and safeguard confidential information.
- **Ethics of AI - Transparency:** competencies that enable to understand the mechanisms of data manipulation and the principle of explainable AI.
- **Ethics of AI - Human Agency:** competencies that enable to understand the human role in AI, the key features of computer systems and the development of critical thinking.
- **Social Implications - Advantages and Disadvantages:** competencies that enable to assess the positive and negative consequences of AI's integration into society, locally and globally.
- **Social Implications - AI in Everyday Life:** competencies that enable to recognize and analyze AI's influence on daily experiences, from the role of new technologies to digital citizenship and future jobs.
- **Social Implications - Environmental Impact:** competencies that enable evaluating the ecological footprint of AI technologies, identifying potential sustainability challenges and opportunities.
- **Social Implications - Fakes and Misinformation:** competencies that enable to understand AI's role in generating and combating fake content and misinformation in digital spaces, taking GAN technology and deepfakes into account.

- **Social Implications - Diversity:** competencies that enable to comprehend the implications of AI on biases related to gender, subgroups, culture and other factors, promoting inclusivity.

However, it is important to note that this model has not yet been validated.

4.5 Emerging Competencies

This level extends AI competencies with a focus on Generative AI. As there are no comprehensive competence frameworks for this emerging domain, we have classified the competence field into four following categories:

GAI model types describe the type of model / concept / algorithm used. Common GAI types are foundation models, generative adversarial networks (GANs), variational autoencoders (VAEs), and transformers [33, 34, 35].

- Foundation models are large-scale neural networks that can perform multiple tasks across different domains by pre-training on a large corpus of data and fine-tuning on specific tasks. Foundation models can generate text, images, audio, or video from natural language queries or descriptions.
- GANs are a type of neural network that consist of two competing models: a generator that creates fake data and a discriminator that tries to distinguish between real and fake data. GANs can generate realistic and diverse images, videos, or audio from noise or latent vectors. Some examples of GANs are StyleGAN and BigGAN, which can generate high-resolution face images and natural scene images respectively.
- VAEs are another type of neural network that encode data into a latent space and decode it back into a reconstructed output. VAEs can generate new data that are similar to the original data but with some variations. VAEs can also perform tasks such as data compression, denoising, or interpolation.
- Transformers are a type of neural network that use attention mechanisms to process sequential data, such as text or speech. Transformers can generate fluent and coherent text, speech, or music from previous context or input. Transformers can also perform tasks such as machine translation, text summarization, or question answering.

Based on those model types, we can define initial competencies. We use the following levels:

- Knowing a model type: The basic level just means that an individual knows about the existence and the general principles of a model type.
- Selecting and applying a model type means that an individual knows the purpose, can select and use it for a certain problem class.
- Understanding the algorithm of a model type means a deeper understanding of the underlying model and algorithm.
- Training and adapting a model type means that an individual can set up an own version including training and finetuning.
- Developing a model type can develop own variants of a model type.

This competence category is strongly related to the AI competence level. It is a prerequisite to understand AI algorithms such as machine learning and neural networks. On the upper levels, further base competencies are required such as data handling, programming and statistical competencies.

GAI tools and applications: This class of competencies contains the responsible use of tools for content generation.

General competencies describe the basic usage of GAI tools including the preparation

- Tool selection: Knowing and selecting potential tools for content generation
- Tool understanding: Understanding the model types and their possibilities
- Tool validation: Understanding the potentials and limitations of specific tools.

For each type of content, we recommend to use the following descriptions:

- Generating content (text, 2/3D image, video, sound / speech)
- Transforming content (text, 2/3D image, video, sound / speech) such text to speech
- Modifying content (text, 2/3D image, video, sound / speech) including the refinement of content
- Validating content (text, 2/3D image, video, sound / speech)
- Referencing content (text, 2/3D image, video, sound / speech) describing the sources appropriately.

We intentionally do not list specific tools but focus on the type of media which is generated / used. Especially in this category, it is necessary to relate to basic and digital competencies. As an example, it is not possible to generate specific outcomes without fundamental knowledge of the domain.

The competence category **GAI Implications** deals with the different implications of GAI such as assessing risks and overcoming limitations / problems. We have derived the following competence categories:

- **Social implications** contain consequences / risks on the social level such as changes in relations between individuals as well as negative phenomena (isolation, over-reliance on AI).
- **Ethical implications** contain consequences / risks regarding ethical aspects such as bias towards specific groups / contents.
- **Privacy implications** contain consequences / risks regarding the use of data and tool usage, e.g. how are images used which are modified by user in specific tools

For each of those competencies, we propose to use the following levels.

- **Knowing** implications describes that individuals are aware that specific risks exist.
- **Assessing** implications describes that individuals are able to assess a specific risk.
- **Overcoming** risks means that individuals have solution / mitigation strategies for known risks
- **Mastering** risks mean that users can identify, assess, and overcome new and unknown risks by themselves.

This category is very complex and requires knowledge and skills on basic, digital and AI topics. However, it is highly necessary for a conscious and responsible use of technologies and tools.

The last category of our framework considers **GAI attitudes** and is strongly related to the GAI implications category. We have identified the following competence categories:

- **Responsible Use:** Individuals use technologies and tools in a responsible way, e.g. not for criminal or unethical purposes.
- **Positivity:** Individuals have an open and positive attitude towards GAI technologies and tools.
- **Critical use:** Individuals are able to question the quality of GAI processes and outcomes.
- **Confidence:** Individuals are confident about the usage and are able to overcome insecurities.

This last category is in particular important for a responsible use but also to deal with emerging technologies. It is strongly related to basic and digital competencies such as openness, willingness to change or agility.

5 Usage Scenarios

In the following, we describe two short usage scenarios to demonstrate how the model should be applied. The scenarios focus on the domain of school education, in particular for curriculum developers and teachers. The scenarios serve as a first evaluation to demonstrate the plausibility and usefulness of our approach.

5.1 Scenario 1: AI Policy / Strategy Design

For schools / school administrations, it is of high importance that an AI policy and strategy is developed to make sure that schools are "AI ready" [36].

Strategy development team selection: In a first step, a team needs to be selected, consisting of administrators (e.g. principal, school administration), teachers from a variety of subjects, parents and students.

Strategy development: It has to be ensured that clear principles for the use of GAI are determined. This includes the development of guidelines (how to include GAI in different subjects) regarding the use of tools across subjects as well as pedagogical and didactic principles. It should be the assumption that GAI will be used by teachers and students regularly. The GAI framework can be used to identify the main topics of the strategy: How and which generative technologies can and should be used? How to address concerns regarding privacy and plagiarism? How to qualify existing staff?

Teacher Qualification: In this step, all teachers need to develop their competencies - it is essential that all teachers have a basic understanding regarding GAI technologies and tools on a level that they know and use tools. Furthermore, teachers need to develop an understanding how their subject-related competencies and pedagogical

competencies are affected: How can GAI tools be used in a certain subject (e.g. as input for creative processes), how can GAI tools be used in the classroom and what are the implications (e.g. changing assessment formats). For each teacher, a profile of the GAI framework, including the basic levels should be built.

After this strategy process, the following usage scenario would follow.

5.2 Scenario 2: Curriculum Design

A school should be very clear how to incorporate GAI in their curricula - currently, there are very few national / regional curricula which specifically address AI and even less GAI [23].

Design of Curricula: Based on the strategy, it needs to be elaborated how to include (G)AI in different subjects. This means that different subjects need to be addressed, e.g. how to include AI in computer science, how to incorporate basic statistics in mathematics. Besides, AI competencies need to be continuously addressed across subjects, in particular regarding the GAI implications (e.g. social implications of deepfakes) and GAI attitudes (e.g. responsible use, plagiarism) categories. Competencies from the GAI level can be selected as starting points for curriculum design. Besides, it is necessary to connect those competencies with the basic level (e.g. basic statistical concepts, basic digital tools, basic programming). The outcomes are revised curricula and student competence profiles for different grades.

Operational processes: When curricula are implemented, the GAI framework can be used to revise pedagogical and didactical concepts, for example when planning or revising courses. As an example, typical homework or project-based learning needs to be revised. When GAI is used, students need to be supported how to use GAI for assistance, how to reference results from GAI and how to use basic subject related knowledge when using GAI (e.g. naming correct concepts when formulating prompts).

Overall, the GAI Framework can be used in different processes, from strategy building to course planning.

6 Discussion

To our knowledge, our model is the first model for Generative Artificial Intelligence competencies. The GAI framework integrates existing models for basic and digital competencies, domain specific competencies for educators as well as AI competencies with an additional layer on Generative AI competencies.

The integration is important on different levels: Models for digital [11] or digital transformation [22] competencies are well established and utilized in both education and industry. These need to be extended to ease the process of implementation and change. Specifically, the educational sector widely uses the DigCompEdu framework [9] which is also incorporated in our framework – by this, we can build upon and extend this base work when implementing new competencies for example in teacher education.

The model is not intended to be complete as we cannot incorporate all technologies and tools which emerge currently weekly or monthly - these need to be included when

building competence profiles, i.e., adapting the competence framework for a certain scope or role (e.g. competence profile for a middle school computer science teacher).

7 Conclusion and Outlook

In this paper, we have outlined a comprehensive framework for Generative Artificial Intelligence. It connects three layers, combining basic / digital / domain-specific competencies with AI and GAI competencies. As a competence framework is always changing due to emerging trends and technologies, we aim to use this framework as a starting point to develop a comprehensive and dynamic artifact as a starting point for school transformation towards AI readiness.

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