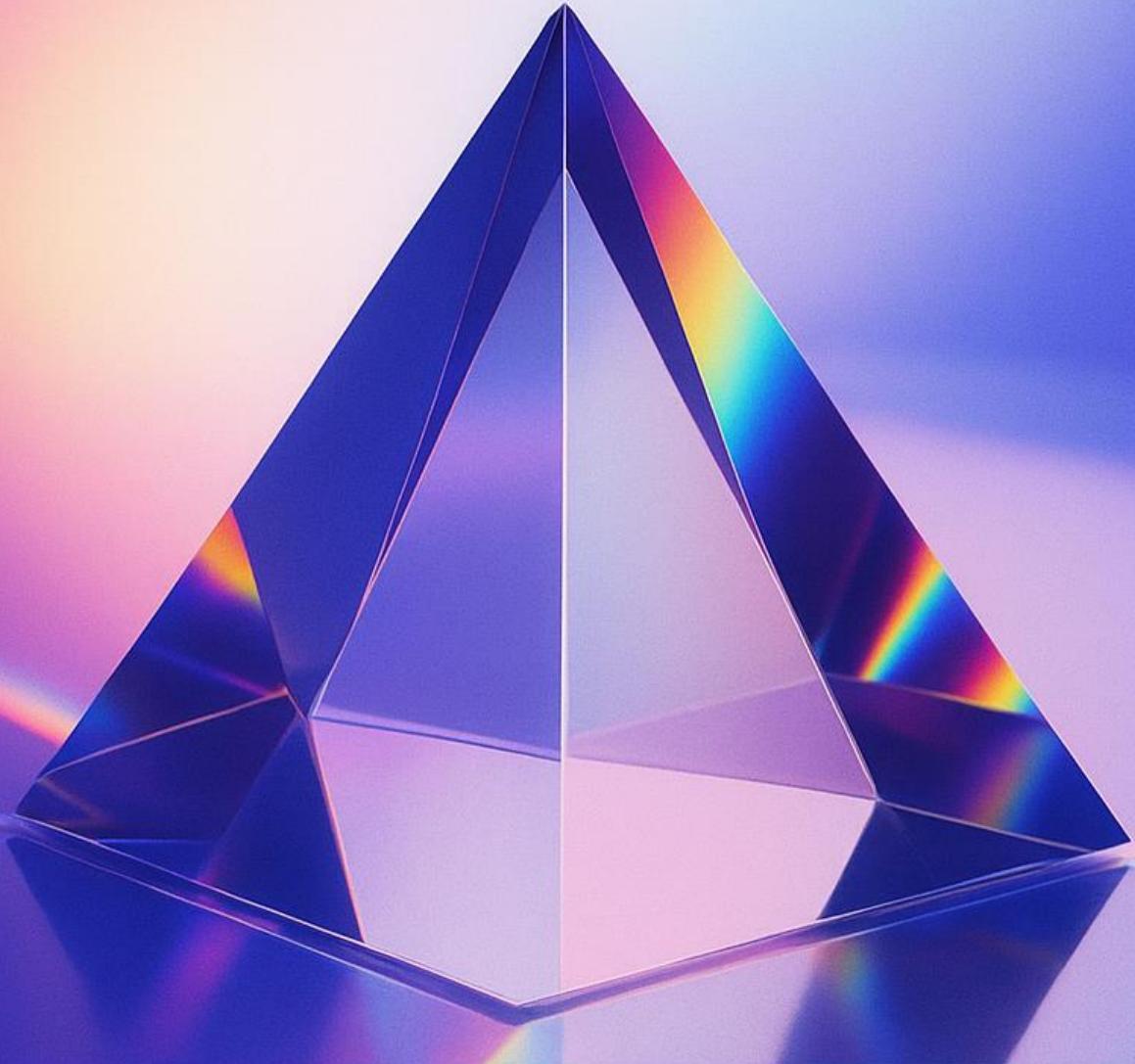


Rewriting the Learning Code

Development of a curriculum-aligned generative AI learning assistant to address the teacher shortage



Mykyta Kushynov & Tarek Almallouhi

HELEN PARKHURST

PROFIELWERKSTUK

COMPUTER SCIENCE

Rewriting the Learning Code

Applications of Artificial Intelligence (AI) in Education

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“Tell me and I forget. Teach me and I remember. Involve me and I learn.” – Benjamin Franklin

Foreword

Dear Reader,

This PWS has been an important learning experience for us, both academically and personally. We chose the topic of teacher shortage and the role of artificial intelligence because we see these developments happening around us every day. As students, we experience the effects of the shortage in our own classrooms, and at the same time we are surrounded by rapidly advancing AI technologies. This combination inspired us to explore whether AI could contribute to a more accessible and effective education system.

During the project, we encountered several challenges, such as analyzing complex research reports, understanding technical AI concepts, and finding a balance between the perspectives of teachers and students. At the same time, this process taught us a great deal about research methods, collaboration, and ethical questions that come with new technologies.

We would like to thank the school board of Helen Parkhurst and ASG, who assisted us with organizing the survey and supporting our goal to contribute to addressing the teacher shortage; to all students and teachers of Helen Parkhurst who participated in the survey and follow-up interviews; to the JoJoSchool team, who generously shared their technical expertise during our meeting; and especially to our supervisor, Bülent Topal, for his technical knowledge, guidance, support in setting up technical requirements, and overall supervision throughout the project. We wish you an enjoyable reading!

Yours faithfully,

Mykyta Kushynov & Tarek Almallouhi

Abstract

This research project examines the global teacher shortage and its consequences for the quality of education and explores the potential of artificial intelligence (AI) as part of a possible solution. Through a literature review, survey, and interviews with teachers and students, we investigated where the shortage is most severe, which tasks teachers struggle with most, and how AI tools could support or partly take over certain responsibilities. The results showed that the teacher shortage negatively affects teacher workload, learning outcomes, and education worldwide. Teachers and students both see possibilities of AI being used in education, especially for explanations, automation, and feedback. But they also show concerns regarding accuracy, bias, and the importance of human interaction.

Based on the results we gathered, we designed and developed an interactive AI education coach prototype that provides book-specific learning support, multilingual explanations, and voice-based interactions. The goal of the prototype is to demonstrate how AI could be a possible solution to reduce teacher workload and thus help tackle the problem of teacher shortages. This project shows that AI cannot replace teachers but can support them and help them when used ethically and responsibly.

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Notes

1. “deep” refers to a vast number of hidden layers
2. “hallucination” refers to inaccurate or deceptive results generated by AI models

List of Acronyms and Abbreviations

AGI – Artificial General Intelligence

AI – Artificial Intelligence

ANI – Artificial Narrow Intelligence

ANN – Artificial Neural Network

API – Application Programming Interface

ASI – Artificial Superintelligence

DL – Deep Learning

EI – Education International

FM – Foundation Model

GPT – Generative Pretrained Transformer

LLM – Large Language Model

LPI – Learning Policy Institute

ML – Machine Learning

NLP – Natural Language Processing

OECD – Organization for Economic Co-operation and Development

SDG – Sustainable Development Goals

STT – Speech-to-Text

TTS – Text-to-Speech

TTV – Text-to-Video

TTF – Teacher Task Force (UNESCO)

UIS – UNESCO Institute for Statistics

UNESCO – United Nations Educational, Scientific and Cultural Organization

General Introduction

Context

There is currently a major teacher shortage worldwide. Artificial Intelligence (AI) has undergone significant development in recent years – both technological and ethical – and has proven to hold great potential as a valuable companion in many industries, including education.

AI-driven technologies are revolutionizing the academic domain by enhancing learning experiences, automating routine tasks, and offering personalized support to students in their personal development. From automated grading to AI-powered intelligent tutoring systems, AI is reshaping the fundamentals of learning.^{[1][2][3][4][5]} AI is transforming education in multiple ways, such as:

- Automating administrative tasks
- Real-time feedback and progress tracking
- Adaptive learning platforms
- Enhancing accessibility and inclusivity
- Intelligent content creation
- Intelligent tutoring systems

With the increase in the number of tasks of teachers that can be (partially) taken over or supported by AI, the number of ethical concerns – partially related to the growing reliance on AI – is growing as well. The ethical challenges that are involved in the advancement and progressive adoption of AI-focused technologies in education include accessibility, bias and fairness, and data privacy.^{[4][5]}

Nonetheless, there is room for different perspectives too. Not only on a current, but also on a future basis, AI can provide support to teachers –and, most importantly to students – by improving efficiency and flexibility.^{[1][2][5]}

Problem Statement

Schools everywhere are having trouble because there aren't enough teachers. This means classes are bigger and students don't get as much help as they should. Teachers already have a lot to deal with, such as knowing how to deal with each individual student, preparing lessons and having too much paperwork. Some schools try out digital tools, but most of the time those don't really fix the issue. In the end, there's this gap between what schools want to do for students and what they can provide. And as time moves on, this gap keeps getting bigger.

It is not only one group that has this problem:

- Students get less attention and can't always learn the way they need.
- Teachers are overloaded with work and stress, and some even stop teaching.
- Schools struggle to keep enough staff and still promise a good education.
- Parents worry about how their kids are doing and what future they will have.
- The government is supposed to come up with plans, but it's not an easy fix.
- Society also feels it, because without good education the future workforce and community both suffer.

It can be seen on this graph how the total number of teachers needed until 2030 is distributed among all parts of the world, namely Oceania, Central Asia, Latin America and the Caribbean, Eastern Asia, Northern Africa and Western Asia, South-Eastern Asia, Europe and Northern America, Southern Asia and Sub-Saharan Africa. From the graph you can derive that Sub-Saharan Africa and Southern Asia are parts of the globe that are experiencing the teacher shortage the most, and Oceania and Central Asia the least.^[6]

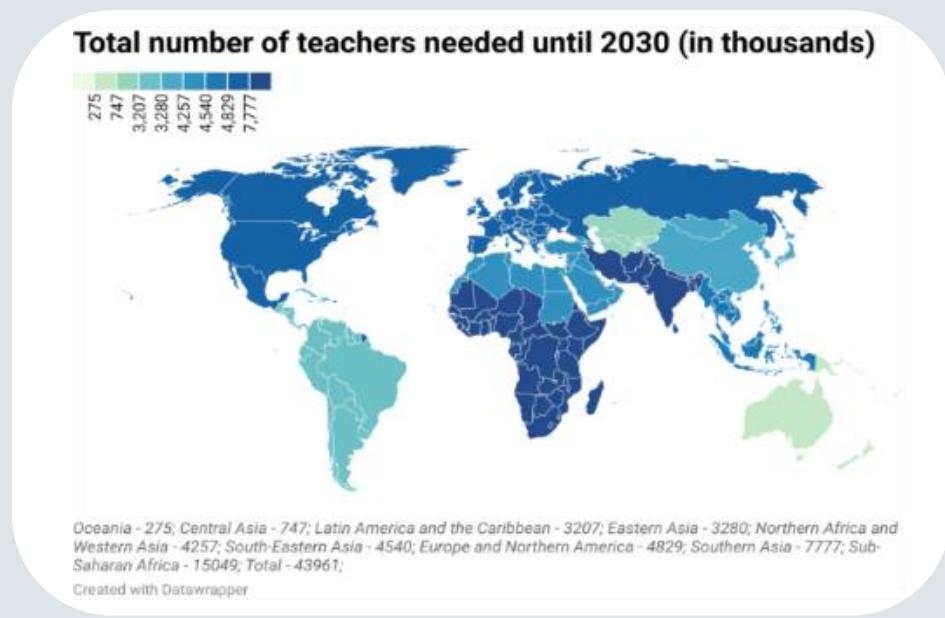


Figure 1 Total number of teachers needed until 2030^[6]

Relevance

Education is the basis for everything later in life. If there aren't enough teachers, students won't get the support they need, and some students will fall behind or even lose interest in school. That doesn't just stay in the classroom, they will also have to deal with it when they look for work or want to study more after school. Additionally, it can increase the gap between students, particularly between those who already have more opportunities and those who don't. Because of this, the teacher shortage is not only a school issue but rather a larger social one.

Considering the fact that the teacher shortage is growing in many parts of the world, which can lead to a decrease in literacy among children, it is of great importance to devise a way to make a meaningful impact on the issue. The question that arises is as follows:

Research Questions

How can an interactive AI education coach contribute to solving the teacher shortage in education?

- What are the consequences of the teacher shortage for the quality of education?
 - Where is the shortage most severe?
- Which tasks of teachers can be (partially) taken over or supported by AI?
- What are the wishes, concerns, and expectations of students and teachers regarding the use of AI in education?

Research Aim

At the end of this project concerning the applications of artificial intelligence in education, we hope to make a significant contribution to solving the problem. We intend to complete the project by presenting a prototype of the specific solution and submitting a research-and-design-rapport including the description of the process and the product as well.

Scope

In the design phase we will not be building our own LLM, for such vast time and resources are not available. That is why we will be using a

more fitting alternative in frames of our project – API of an already existing LLM, such as GPT-4o, or a foundation model of an already existing LLM. In the first case, it will be much faster in terms of execution, though the fine-tuning – or in other words, adjustment to our preferences – will be limited or absent at all. As a matter of fact, we will not be focusing on the topics, such as machine learning (ML), neuron networks (NN), and deep learning (DP), for it lies beyond the scope of our project, as it was emphasized earlier.

Structure of the Paper

In this project we will be using multiple research methods. Firstly, we are going to conduct preliminary research 1 – using a literature review research method –, to visualize existing knowledge about the problem. We will be analyzing information relevant for this project, which may provide us with necessary knowledge before we have begun the design phase. Then we will use survey or interview as a primary methodology for preliminary research 2. There we will be investigating the opinions of certain stakeholders involved. These two preliminary research studies will lay the foundation for creating the product requirements document, for we will have gathered all the information needed to meet the expectations of the target group. Once we're done with the design phase of our product, we will begin gathering opinions of the future product consumers. We will be using survey as our primary research method to determine whether our product can indeed serve as a worthy alternative for the traditional education system to address the teacher shortage problem. In the survey, you measure a collection of factors under the same circumstances across a group of people. This is usually done using a questionnaire if approaching a large group of people is the goal, and an interview if you want to reach a smaller group.

Research Phase

Introduction

In order to acquire the necessary knowledge for the design phase, we have come up with the following preliminary studies in relevance to the temporary research question.

The first preliminary study focuses on visualizing the existing knowledge about the specific problem.

- What are the consequences of the teacher shortage for the quality of education and where is the shortage most significant?
- Which tasks of teachers can be successfully (partially) taken over or supported by AI?

The second preliminary study focuses on functional analysis and aims to describe the background information for the purpose of developing the product, whereby the following question will take the basis:

- What are the wishes, concerns, and expectations of teachers regarding the use of AI in education?

Methodology

In part I – Theoretical Framework –, we will be using literature review as a primary research method. In literature review, you collect written information from (scientific) papers, books, reports, journals etc., to contextualize the topic, or to assess trends within a research topic.

In part II – Function Analysis –, we will be using takes place by using the survey methodology or by interviewing certain stakeholders involved.

Theoretical Framework



Chapter II

Consequences of the teacher shortage for the quality of education

Introduction

This paper examines the growing problem of teacher shortages and how it affects the quality of education worldwide. Education systems everywhere are feeling the effects of too few teachers, leading to larger classes and more strain on schools. We review recent studies and reports (from UNESCO, OECD, education research institutes, etc.) to understand what causes teacher shortages, where they are worst, and how this crisis can harm student learning.

Around the world, many countries report that they lack qualified teachers. UNESCO and other global studies warn us that teacher shortages have become a crisis undermining education.^{[6][7]} In fact, UNESCO projects that an additional 44 million primary and secondary teachers are needed by 2030 to meet basic education goals worldwide.^[10] The shortage is not only in poor countries: even rich regions like Europe and North America face large shortages when many teachers retire or quit.^{[8][11]} This paper explores why there are not enough teachers, what happens in classrooms and schools as a result, which regions struggle the most, and what actions experts suggest.

Definition of Teacher Shortage

A teacher shortage generally means that the demand for teachers exceeds the available supply. In other words, there are not enough qualified teachers to fill all teaching positions. One way to say this is: if “the number of teaching jobs available (demand) exceeds the number of teachers available to fill them (supply)”, we have a shortage.^[12] Another way to describe it is that a school or school system has unfilled vacancies or has to hire uncertified or underqualified people because they cannot find enough trained

teachers.^{[12][13]} This shortage can be general (across all subjects and grades) or specific (for certain subjects like math or in certain areas like schools in small remote areas).^{[13][14]} In practice, a teacher shortage often shows up when schools cancel classes, increase class sizes, or rely on substitute and novice teachers to cover positions.^{[6][13]}

Causes of Teacher Shortages (global perspective)

Experts identify many causes of teacher shortages around the world:

- Low salary and benefits. In many countries, teacher salaries can't compete with other professions. For example, in some parts of Africa teacher pay is below the poverty line.^[15] Even in developed countries, teacher pay often falls behind, making people choose other careers.^{[7][14]}
- Difficult working conditions. Teachers often face large classes, heavy workloads, or lack of resources. Rising demands (like high-stakes testing, digital learning needs, or pandemic recovery) have increased stress. UNESCO notes that increasing workloads and difficult conditions make teaching look bad and pushes people away from the profession.^{[7][16]}
- Low social status and respect. In some countries, teaching is not seen as a high-status profession. This makes it less attractive to talented graduates. Education unions report that limited career progression and low professional status contribute to shortages.^{[7][14]}
- High attrition (teachers leaving). Many teachers quit after a few years. Globally, attrition rates have risen: UNESCO data show the share of new teachers leaving nearly doubled from 4.6% in 2015 to 9.1% in 2022.^[17] Young teachers often leave for higher-paying or less stressful jobs. In the US, studies report that up to 50% of new teachers quit within five years. High turnover contributes greatly to shortages.^{[12][13]}

- Insufficient training. In some places, fewer students are enrolling in teacher education programs than before. For example, in the US the number of people training to teach fell by over 30% from 2009 to 2014.^[18] If too few new teachers are trained, shortages grow when the existing workforce retires or exits.
- Retirement of older teachers. In many countries a large share of teachers is near retirement age. As they retire, huge numbers of new teachers are needed. Europe and North America have aging teacher workforces, creating large vacancy numbers.^{[15][17]}

Consequences for Education Quality

Teacher shortages hurt the quality of education in many ways. When there are not enough teachers, classes become larger and less effective. UNESCO reports that a worldwide shortage “leads to larger class sizes, overburdened educators, educational disparities”.^[6] In large classes students get less individual attention, and teachers spend more time on discipline and routine tasks rather than teaching. Schools may cancel classes or programs if a teacher cannot be found. For example, U.S. researchers found that teacher shortages often lead schools to cancel elective courses or remedial help, and to staff classes with substitutes or teachers untrained in the subject.^[13] This can directly affect student achievement.

Substitute or under-qualified teachers are one common temporary solution. Learning Policy Institute notes that shortages have forced some districts to rely on underprepared teachers or substitutes, who tend to leave quickly (sometimes 2–3 times the rate of well-prepared teachers).^[13] When students have a chain of substitutes or changing teachers, their learning is disrupted, and they may fall behind. Students in teacher-shortage situations often experience

stress and uncertainty, which can harm motivation and accomplishments.

Moreover, shortages tend to hit disadvantaged or remote schools hardest, widening inequalities. If wealthier areas can attract the few available teachers, poorer communities are left with the largest classes and least-experienced teachers. UNESCO warns that shortages can create “educational disparities” between rich and poor regions.^[6] All these factors mean overall learning outcomes suffer when teacher shortages persist. In other words, research strongly indicates that without enough qualified teachers, both student learning and the quality of schooling drop.^{[6][13]}

Regions Most Affected by Teacher Shortages

Teacher shortages are global, but some regions face especially large gaps:

- Sub-Saharan Africa: This region has by far the biggest needs. According to UNESCO, by 2030 sub-Saharan African countries will need about 15 million new primary and secondary teachers to achieve universal education.^{[16][17]} Current pupil-to-teacher ratios are very high (often over 50 students per teacher), and many teachers are untrained. Growing populations mean most of this gap comes from new classes being added (not just retirements).^[11]
- South and Southeast Asia: Countries like India, Pakistan, Indonesia, and others also require millions of additional teachers. UNESCO projects about 7.8 million extra needed in Southern Asia and 4.5 million in South-eastern Asia by 2030.^[17] These regions expanded school enrollment rapidly in recent decades and are still catching up on hiring. If they do not train and hire more teachers quickly, many students will have very large classes or second-grade teachers.

- Latin America & the Caribbean: Many countries here already have relatively better access to teachers but still face shortages in remote or poor areas. UNESCO and Latin American organizations report shortages of about 3.2 million teachers by 2030, most of which is due to expected teacher attrition (retirements and quits).^[11] Some countries like Brazil, Colombia, or Mexico find it hard to staff rural schools or certain subjects (e.g. STEM fields). In 2021 UNESCO launched a regional strategy to attract more teachers in Latin America.^[8]
- Europe and North America: Surprisingly to some, high-income regions also report many shortages. UNESCO notes that Europe and North America could need an additional 4.8 million teachers by 2030 (mostly to replace those leaving).^[11] In the U.S., for instance, nearly half of school leaders now say teacher vacancies are hurting instruction.^[9] In parts of Europe like Spain and Germany, shortage is severe in subjects like math, science, and foreign languages. For example, Spain had over 700 open math teaching positions in 2023.^[15] Many European countries see waves of retirements coupled with declining enrollment in teacher education, making shortages worse.
- North Africa and West Asia: Countries like Egypt, Morocco, or Iraq also face shortages. UNESCO estimates about 4.3 million teachers will be needed in North Africa and West Asia by 2030.^[17] These gaps are partly due to both expanding schools and insufficient hiring budgets. Conflict and instability in some areas exacerbate shortages.
- Other regions: Even in smaller countries or those with good education systems, local shortages exist. Many Pacific Island nations or parts of the Middle East hire foreign teachers to cover gaps. Overall, surveys of educators around the world (such as the recent Global Status of Teachers report) found shortages in nearly all countries, especially in special education and STEM subjects.^[10]

Statistics

UNESCO's 2024 teacher report compiles these findings: globally, some 44 million new teachers (primary and secondary) are needed by 2030.^[10] Of this gap, about 63% in Sub-Saharan Africa comes from new positions (population growth), while in Europe, North America, Latin America most of it comes from anticipated attrition.^[11] Regions like Eastern Asia and Southern Asia have reduced their projected needs in recent years by improving teacher recruitment, but still face large numbers (3.4 million and 7.8 million needed, respectively).^[12] In contrast, many smaller or wealthier systems need fewer new teachers, but even they report difficulty filling positions in certain subjects. For example, in the U.S. about 50 states report shortages in math, science, and special education.^[13]

Possible Solutions

Experts agree that addressing teacher shortages requires long-term, multi-faceted solutions. Key ideas from the research include:

- Improve salaries and career paths. Raising teacher salaries and benefits is often the top recommendation. The UNESCO–Teacher Task Force argues that higher wages for the profession are crucial.^{[7][8]} Countries with strong teacher recruitment (like Finland, South Korea) invest in good pay and clear career progression, which helps them retain teachers.^{[14][16]} Bonuses or loan forgiveness for teachers in high-need subjects or areas can also help attract staff.
- Better working conditions and support. Reducing class sizes and workloads is important. Governments and schools can hire more support staff (counselors and coaches) so teachers can focus on teaching.^{[6][7]} Improving schools, providing teaching materials, and

involving teachers in decision-making can raise job satisfaction.^{[7][8]} Mentor programs for new teachers and regular professional development also help novice teachers stay in the profession. UNESCO highlights the need for “*attractive career pathways with equitable access to professional development, autonomy, and purpose*” to keep teachers motivated.^[10]

- Train and hire more teachers. A key step is simply to bring more people into the profession. Governments can fund more places in teacher colleges, give scholarships, or create faster routes for adults who want to change their careers. In some countries, mid-career professionals or retirees are trained quickly to teach. This can also help bring more diversity into schools, like teachers with different languages or backgrounds.^[17]
- Focus on shortage areas. In many countries, math, science, and rural schools have the hardest time finding teachers. Offering extra pay, housing support, or relocation bonuses can attract teachers to those areas. Careful planning also helps—using data to see where new teachers are needed most.^[8]
- Keep current teachers. Since many teachers quit after a few years, making the job more sustainable is critical. Policies that give teachers time off, reduce stress, and show respect can encourage them to stay. Recognizing good work and involving teachers in designing reforms makes them feel valued.^{[7][8]}
- Work together internationally. The teacher shortage is part of the global goal of “Education for All.” UNESCO and other organizations call for governments to create national teacher plans that cover pay, training, workload, and career development. Sharing solutions between countries can speed up progress.^{[7][10]}

Many solutions take time (training teachers, budget changes), but also some immediate steps (hiring retirees part-time, using online

platforms to support teachers, emergency certification) are used while longer-term strategies develop. Ultimately, reversing teacher shortages means making teaching a respected, rewarding profession that young people choose, and that experienced teachers stay in.^{[7][8]}

Chapter III

**Tasks of teachers that can be successfully (partially)
taken over or supported by AI**

Introduction

Before we start with the design phase of our product, it is rather important to first clarify the theory, particularly what AI is, what the tasks of teachers are, etcetera, so that we understand the main aspects of the topic we will be dealing with. For that purpose, we can formulate the following sub-question: *"Which tasks of teachers can be successfully (partially) taken over or supported by AI?"*

To find out the answer to this question, we will firstly give a brief explanation of AI, and everything it may involve during this project. Then, we will define the tasks, responsibilities and competencies of teachers, and support AI can already provide. Subsequently, it will be explained what the possible consequences of AI adoption in education are and why certain tasks cannot be taken over.

Artificial Intelligence

Brief explanation of AI

Artificial intelligence (AI) is the capability of technologies to perceive their environment and demonstrate a variety of skills and cognitive abilities a human being would have to be in possession of to achieve a defined goal. It is a field of research concerned with creating computer systems that have an ability to perform various functions that require certain level of human intelligence and deduction abilities to do so. Examples of the variety of concerning tasks are learning, problem solving, comprehension, creativity, perception, decision making, and so forth. Furthermore, it covers abilities to see and identify objects, adapt to its surroundings through learning from new information and experiences, and act independently if necessary.^{[30][31][32][33]}

Prominent applications of AI encompass sophisticated web search engines (e.g., Google Search), recommender systems (used by Netflix,

Amazon and YouTube), virtual assistants (e.g., Google Assistant and Siri), autonomous vehicles (e.g., Tesla), generative tools (e.g., ChatGPT and Sora) and supercomputer for chess-playing (e.g., Deep Blue).^[30]

Because of the drastic development of AI through the years, it is no longer considered a subfield of research in computer science, but an individual area of study that pursues multiple objectives, such as learning, reasoning, knowledge representation, planning, natural language processing (NLP), perception, and robotics support. For instance, AI involves a broad range of methods from multiple disciplines to reach its goals, including computer science, mathematics and statistics, neuroscience, economics, psychology, philosophy, and linguistics.^{[30][32]}

Different types of AI

To say that there are many types of AI would not be false, but also not accurate enough.

There are in fact many ways of classifying AI. For this research we will classify it by capability level and by learning approach.

The first classification, by capability level, distinguishes AI based on how advanced it is in terms of intelligence, taking human intelligence as a reference point. There are, namely, three main types of artificial intelligence:

Artificial narrow intelligence (ANI): it is currently the most common type of AI. ANI aims to perform specific procedures, such as natural

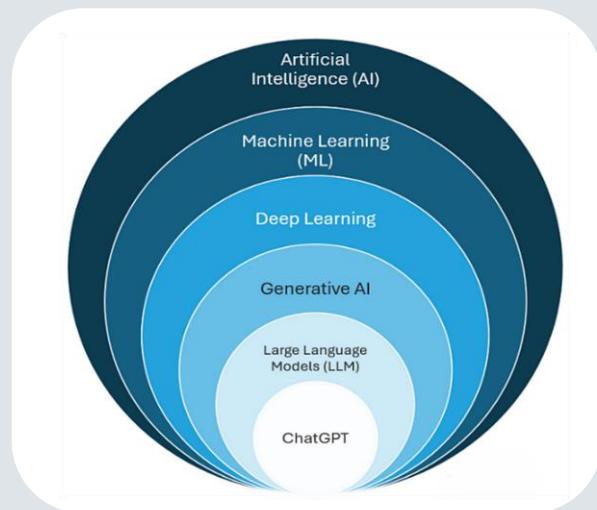


Figure 2 Venn diagram Artificial Intelligence^[38]

language processing (NLP) or speech synthesis. For example, speech synthesis used to mimic the human voice for train announcements is one of the ANI applications.^[33]

Artificial general intelligence (AGI): it is a type of AI that is able to perform intellectual tasks at least as well as a human. AGI has the capability to learn, reason, and adapt to new situations. Although AGI does not yet exist, it is a possible option in the near future, as multiple tech behemoths, such as OpenAI, Google DeepMind and Meta, make enormous investments in its creation.^{[30][33]}

Artificial super intelligence (ASI): it is still a speculative and theoretical concept of what artificial intelligence could become. Cognitive level of ASI is far more advanced than ours, and it can potentially perform any intellectual task with exceptional efficiency and solve problems that are beyond our understanding and capabilities. For instance, an ASI-based system could potentially reverse climate change or develop innovative medical treatments.^[33]

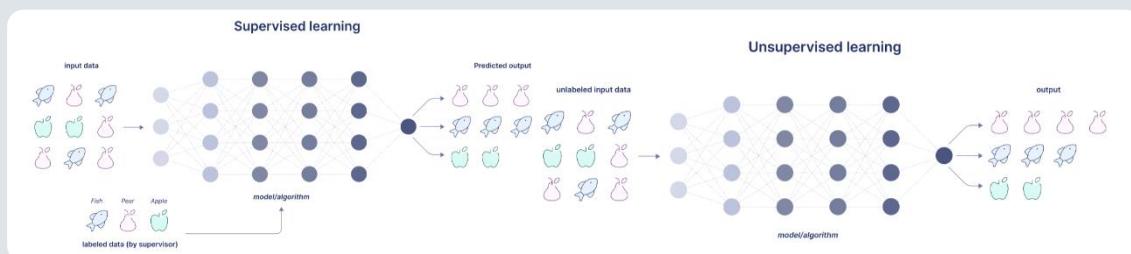


Figure 3 Supervised and Unsupervised learning principle^[40]

The second classification, by learning approach, categorizes AI according to the method by which the model is built, or more precisely, what steps have been undertaken to train the model. In that way, there are, namely, two types of artificial intelligence:

Machine learning (ML): it is a subgroup of AI, which focuses on research and development of statistical algorithms of computational models that can learn from data and generalize to unseen data, and perform given objectives accordingly, without explicit relying on

programming. Instead, it can be done by training these models, using various learning approaches, such as supervised learning (labelled data), unsupervised learning (unlabeled data), and others.

Disadvantage of unsupervised learning – which uses unlabeled data and therefore has no expected predefined output – is that the model identifies patterns solely from the input data, from which it subsequently extracts knowledge. As a reason for that, the model can eventually give low-quality results, for the data might possibly be polluted with unreliable and biased information. With the appearance of early artificial neural networks (ANN) – computational models inspired by the structure and functions of biological neural networks – typically used only one to three hidden layers (shallow neural networks). The introduction of multiple hidden layers, combined with greater computing power and larger datasets, led to the rise of deep learning (DL).^{[32][34][35][36]}

Deep learning (DL): it is subgroup of ML, which aims to operate of multilayered neural networks – between three and several hundreds of hidden layers – to perform tasks such as classification, regression, and representation learning. Through training on large datasets, it enables networks to demonstrate high performance in fields like image recognition, natural language processing (NLP), and speech recognition.^{[37][38][39]}

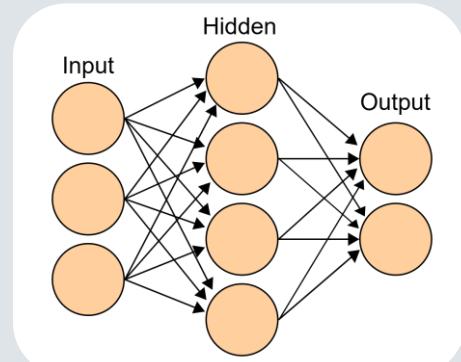


Figure 4 Architecture of Artificial Neural Network^[41]

Generative AI

Now that we have given a brief explanation of artificial intelligence (AI), machine learning (ML), artificial neural networks (ANNs), and deep learning (DL), we could now focus on the main topic of the project: generative artificial intelligence (generative AI).

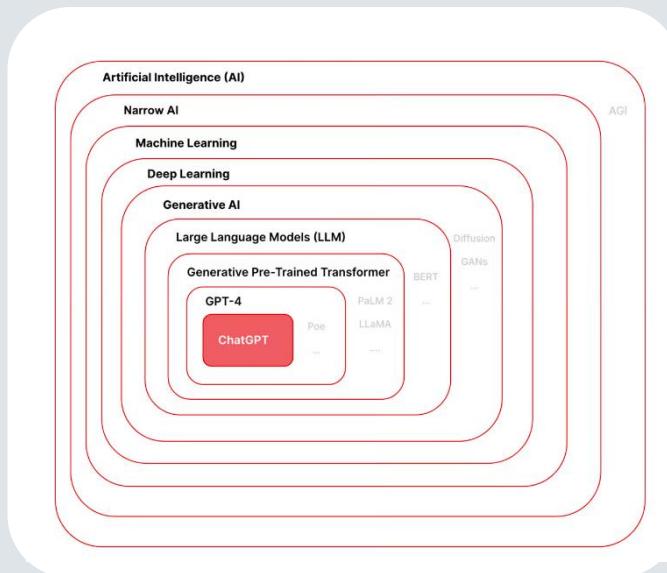


Figure 5 Taxonomy diagram Artificial Intelligence^[39]

The term generative AI refers to the use of AI agents to create new content, such as text, images, audio, videos, and code. In order to have a clear understanding of what generative AI entails, we should first define a few additional concepts, including natural language processing (NLP), foundation model (FM), large language model (LLM), and generative pretrained transformer (GPT).^{[40][41][42][43]}

Natural language processing (NLP)

Natural language processing (NLP) is a subfield of computer science and artificial intelligence (AI) that aims to analyze, design, and use computational systems for the processing of natural language. NLP enables computers to recognize, understand, and generate human-comprehensible text and speech by combining different disciplines, such as computational linguistics, machine learning (ML), and deep learning (DL).^{[43][48][49]}

Foundation model (FM)

In artificial intelligence (AI) sector, foundation models (FM) are machine learning or deep learning models, grounded in artificial neural networks usage, trained on enormous datasets to perform a wide variety of tasks. They serve as a fundament for additional more specialized models, such as large language model (LLM) for text; diffusion models for images; text-to-speech (TTS) models for audio; and text-to-video (TTV) models for video. Their special flexibility – in contrary with traditional machine learning models that are designed to fulfil smaller, more specific, tasks – allow them to deliver better results in broader domains, such as natural language processing (NLP) and speech recognition, by means of a transfer learning where the coherent knowledge is being applied from one task to another.^{[51][52]}

For the reason that building foundation model from scratch is a highly demanding job in terms of time and resources, we will stick to an open-source foundation model or to an application programming interface (API) of a certain generative AI model, such as one of ChatGPT or Anthropic.^[51] Though it has its benefits and drawbacks. Using an open-source foundation model you get your own ready for tuning model, in other words, you can store the foundation model on your server and adjust it to your preferences. You can train the model with specific data sets you want it to comprehend. You can decide yourself what the regulations are and not depend on the host of the model, although it is still a more resource-intensive option. While using an API of a certain generative AI model, the capabilities of an AI model are limited within an API you are using, and furthermore the tuning possibility is absent at all, but your expenses will be minimal, since you only have to pay a tariff for a total of in- and outputted tokens; US\$ 1,250 / 1M inputted tokens and US\$ 10,000 / 1M outputted tokens.^[53]

Large language model (LLM)

Large language models (LLMs) are *deep*¹ neural network models, typically based on transformer architectures, trained on large datasets of diverse content, to understand and generate natural language, and fulfil other natural language processing (NLP) tasks, including text generation, machine translation, question answering, etcetera. Additionally, it uses probabilities and statistics to predict what comes next in a sentence. For example, if the first word in a sentence is “I”, then the probability of occurrence of “am” or “have” next is higher than “are” or “has”. Generative pretrained transformers (GPTs), which are widely used in generative AI chatbots such as ChatGPT, Gemini or Claude, are among the most capable LLMs, and can be fine-tuned based on your preferences.^{[43][46][47]}

Generative pretrained transformers (GPT)

Generative pretrained transformers (GPTs) are a type of large language model (LLM) that use artificial neural network (ANN) principles to produce novel content based on an input via the prompt. The transformer architecture forms the foundation of GPTs. Simply put, a transformer takes an input and “transforms” the input into an output that sometimes may occur in a different format. For example, if it takes an input via prompt that states “What is a dog?”, a GPT may create a written essay describing a dog.^{[43][44][45]}

So, what exactly is a generative AI? Generative AI is a deep learning model that generates novel variable – by means of a generative pretrained transformer – content, in contrast to discriminative models. The novel content can be text, images, audio, videos, and code. Additionally, it utilizes artificial neural networks (ANN) and large language models (LLMs) to generate an output based on an input sequence.^[43]

Tasks, responsibilities, and competency requirements of teachers

Responsibilities

The responsibilities of teachers are divided into three processes: subject-specific process, subject-specific didactic process, and pedagogical process. With the subject-specific process is being meant everything that has to do with the content of the education. The subject-specific didactic process covers the way in which students learn that content. The pedagogical process relates to the learning environment within the school.^[19]

The content of the education (subject-specific process) ^[18]

Guarantee the quality of lessons-structure

1. Use lesson time effectively to transfer knowledge and develop understanding.
2. Promote love and curiosity towards learning and intellectual development amongst children.
3. Consolidate and strengthen the acquired knowledge by setting homework and planning other out-of-class activities.
4. Evaluate regularly on the efficiency of lessons, and teaching approaches.
5. Contribute to the improvement and implementation of an engaging curriculum within the relevant teaching area(s).

The way in which students learn that content (subject-specific didactic process) ^[18]

Guide pupils toward meaningful progress and academic success

1. Take charge of pupil's achievements, performances and outcomes.

2. Be aware of pupils' capacities and their foreknowledge and take these factors into account while teaching.
3. Help students with reflection on their progress and individual needs.
4. Encourage pupils to take responsibility and show ambition in their own work and study.

Demonstrate strong subject and curriculum understanding

1. Have a good knowledge of the relevant subject and curriculum areas and address misunderstandings.
2. Show an understanding of and take responsibility for promoting strong literacy, articulacy and the proper use of a standard language.

Adjust teaching ways to the strengths and needs of pupils

1. Be aware of pupils' developmental stages and individual needs and know when and how to adapt appropriately to meet their physical, social, intellectual, and personal preferences.
2. Understand how several factors can affect pupils' ability to learn, and how best to address these.

The learning environment within the school (pedagogical process) [18]

Establish ambitious goals which inspire, motivate and challenge pupils

1. Create a safe learning environment for pupils with mutual respect.
2. Set high expectations that challenge pupils and allow them to reach their full potential.
3. Demonstrate the standards of behavior, values and attitudes that align with those of the school.

Use assessment in an accurate and productive manner

1. Have a clear understanding of how to assess relevant subject and curriculum areas, including lawful assessment requirements.

2. Make use of multiple kinds of assessments, including formative and summative assessments, to track and maintain pupils' progress on basis of relevant data.
3. Evaluate pupils' progress by giving consistent feedback, both verbal and written, and encourage pupils to reflect upon it.

Ensure a positive and safe learning environment through effective behavior management

1. Manage classes effectively, and use a consistent and fair range of approaches, such as praise, sanctions and rewards, which align with the school's behavior policy.
2. Sustain strong relationships with pupils, exercise appropriate authority, and act decisively when needed.

Execute a broader range of responsibilities

1. Contribute to the wider life and culture of the school
2. Develop professional relationships with colleagues and collaborate toward further improvement of school life.
3. Communicate effectively with the pupils' parents or guardians regarding their accomplishments and well-being.

Consistently demonstrate high standards of personal and professional attitude

1. Build relationships rooted in mutual respect.
2. Show tolerance of and respect for the rights and beliefs of others and ensure that personal beliefs are not expressed in ways that may cause offence.
3. Respect the fundamental values, laws, and beliefs of the country you belong to.

Tasks

Teachers or educators that belong to kindergarten and elementary school instruct young students in academic basics, such as mathematics and reading, to prepare them for middle school. Teachers or educators that belong to high school usually specialize in a certain number of subjects, such as languages (including English, French or German), mathematics, science or history. Hence, they teach students academic content and valuable skills needed for higher education or the job market. Typical tasks of teachers are as follows:

1. Prepare lessons and teach students subjects they specialize in.
2. Determine students' abilities, strengths, and weaknesses.
3. Adapt lessons based on the number of students in the class.
4. Grade students' assignments and exams.
5. Provide students an individual help to improve their abilities or overcome specific challenges.
6. Check attendance and report absences.
7. Prepare substitute teacher instructions when necessary.
8. Write student reports or progress summaries, which are then discussed with the students' parents or guardians.^{[21][22]}

Competency requirements

Statutory competency requirements in education in the Kingdom of the Netherlands have been since August 1, 2017, in force. They apply to all teachers in primary, secondary, and vocational education. The competency requirements are established in "het Besluit bekwaamheidseisen onderwijspersoneel"

. They describe the minimum knowledge, and skills teachers must possess. Schools may only appoint teachers who meet the competency requirements when recruiting new personnel. In addition to these requirements, schools may establish additional standards with which the staff must comply.^[19]

Teachers who do not comply with all the requirements must be given the opportunity to learn them, to still be able to claim the specific role. Further agreements are made with the school. These requirements are drawn up by teacher committees and describe what it takes to be a teacher. The competency requirements, which serve as reference points for teacher training and competence maintenance, are defined by the teacher committees and describe what the candidate must know to be a teacher.^[19]

In order to teach the candidate must possess the following competencies:

- Subject-specific competence
- Subject-specific didactic competence
- Pedagogical competence

Subject-specific didactic and pedagogical competences are furthermore divided into the subgroups: knowledge and expertise. See source ^[20] for detailed information.

Subject-specific competent means that the candidate must at least:

- a. have a thorough knowledge of the content of his curriculum area.
- b. be above the curriculum they teach.
- c. be able to compile, opt or adjust the curriculum so that the students can effectively learn it.

- d. be able to make connections with day-to-day life, job and science, from his/her subject-specific expertise.
- e. be able to contribute to the general education of their students.
- f. keep their subject-specific knowledge and expertise up to date.

Subject-specific didactic competent means that the candidate:

- a. makes the subject content learnable for their students, in coordination with the colleagues and in accordance with the educational policy of the school.
- b. is able to convert the subject content into the curricula or learning paths.
- c. converts the subject content by means of professional, development-oriented methods, in which at least following elements are recognizable:
 - i. they establish a clear relationship between the learning goals, the level and the characteristics of the students, the subject content and the use of various methods and resources.
 - ii. they follow the development of the students, alongside performing the teaching duties.
 - iii. they consistently and adequately test and analyses whether the learning goals have been achieved and how they were achieved.
 - iv. they adjust the teaching approach, if necessary, in accordance with the analysis.
 - v. they keep teaching approaches up to date with relevant developments.

Pedagogical competent means that the candidate:

- a. by means of professional, development-oriented methods and in cooperation with their colleagues can establish a safe,

- supportive, stimulating and ambitious learning environment for the students.
- b. monitors the development of the students' academic performance and behavior and adjusts their teaching approach accordingly.
 - c. contributes to social-emotional and moral development of their students.
 - d. can adjust their pedagogical approaches with their colleagues and other people involved.
 - e. contributes to the citizenship education and further development of the student to an independent and responsible adult.
 - f. keeps his pedagogical approaches up to date with relevant developments.

Ways in which AI is transforming education

AI is developing drastically and therefore transforming education in multiple ways.

Automating administrative tasks

One of the ways in which AI is transforming education is the ability to automate routine administrative tasks. AI-powered systems can perform the evaluation of student work, including multiple-choice and short answer questions, and even coding and essay-style assignments.^{[23][28]}

For example, Gradescope is an AI-based grading system that evaluates students' assignments and offers detailed feedback to both teachers and students. Turnitin, for instance, uses AI to detect plagiarism in various types of content, providing similarity reports. Another example is an AI-driven tool Remind that

helps making mutual communication between teachers, students, and parents or guardians more efficient.

Real-time feedback and progress tracking

AI-driven agents are highly effective at providing real-time feedback and monitoring students' progress. By examining students' data, these agents can determine patterns and trends, giving valuable insights into students' learning progress.^{[23][28]}

Educational platforms such as Khan Academy use AI algorithms to analyse students' performance data, creating personalized exercises and video lessons that help students strengthen their learning more effectively. In addition, AI-powered tools like Quizziz make learning more efficient, by creating interactive and educational quizzes that provide instant feedback.

Adaptive learning platforms

AI-based educational platforms use algorithms to evaluate students' strengths and weaknesses, adapting to the needs of each individual learner. These algorithms analyze students' learning patterns and make real-time adjustments to the difficulty of the content, learning style, and pace, ensuring the learning experience meets each student's needs.^{[23][28]}

For example, adaptive learning platforms like ALEKS, Knewton, and DreamBox enhance individual student development by identifying knowledge gaps and providing personalized lessons, offering a tailored educational experience.

Enhancing accessibility and inclusivity

Schools that are a part of a traditional education system often struggle to provide students with various types of disabilities. The learning, physical, and developmental disabilities a sever number of students must deal with are dyslexia, dyscalculia, dysgraphia and many more.^[6] Because of this it can be quite difficult for schools to provide students with necessary individual support so that fair and efficient learning on an equal footing with their peers is guaranteed. That is when artificial intelligence comes to hand, which can convert written text into spoken words and vice versa. AI-driven agents can adapt the learning system to each individual student considering these liabilities, and complementing the gaps the common education system cannot often deal with.^[28]

Good examples of AI tools that enhance accessibility and inclusivity of education are Immersive Reader, which is provided by Microsoft, Read&Write and Otter.ai. They offer literacy support by breaking text down into more comprehensible chunks, highlighting text or offering transcription services to help students with hearing impairments.

Intelligent content creation

AI can be used to create various content, both text and video, such as practice assignments, quizzes, and presentations, which can be applied in educational matters.

One of the examples of the platforms where AI agents are being applied to generate video content are Synthesia and HeyGen. Synthesia and HeyGen can generate AI videos of high-quality featuring AI avatars and voiceovers. It opens possibilities to create engaging video content for digital lessons and courses, by simply writing a prompt and choosing various customizations on your own taste.

One of the best ways of effective consuming of information is gamifying learning. It is especially applicable for younger students who tend to show lack of concentration and motivation. With the learning gamified is it possible to make learning more fun and encouraging. Applications that enhance AI agents for creation of interactive gamified learning content are Quizlet and Kahoot!.^[28]

Intelligent tutoring systems

Tutoring systems enhanced with AI-technologies allow users to perform simulations of interaction between a student and a teacher. These systems provide students with real-time assistance at any time. They assess a student's performance and identify areas where improvement is needed, providing students with immediate feedback on assignments, and guiding them to further improvement.^{[23][28]}

Carnegie Learning's Math Solutions and Duolingo are prominent examples of AI-driven educational platforms that provide students with instant feedback, personalized learning and adapt to each learner's pace and progress.

What are the possible consequences of AI taking over tasks?

With the development of AI there is a growing number of ways in which it can transform education. This can lead to multiple consequences, both positive and negative.

Perspectives

Artificial intelligence may benefit education in multiple ways. First, improvement of the quality of the existing education system. With the enhancement of AI-technologies in education it may

lead to a great increase in efficiency, through among other things automatizing routine administrative tasks of teachers, such as grading assignments and scheduling.^[24] Instead of wasting time on this kind of repetitive task it may be better for teachers to increase the focus on the pedagogical process rather than subject-specific or subject-specific didactic process. This could help to spare teachers more time for socializing with the students and creating special teacher-student bonds, rooted in mutual respect. Furthermore, AI-enhancement will provide support to students with disabilities through various tools and approaches, including speech-to-text and text-to-speech tools.^[28]

Second, accessibility for students from countries with limited number of teachers and quality of education subsequently. Especially in multiple parts of Africa, it is difficult to provide students with qualitative education. Generative AI has huge potential to address this problem as an individual source of knowledge provision, acting on its own without severe use of teachers, and among other things to accelerate progress towards SDG 4. SDG 4, or Sustainable Development Goal 4, aims to provide inclusive and equitable education and guarantee vast learning opportunities for all.^[25] This may help make classrooms available to all, including those who speak different languages, spread across the world or suffer from illness.^[29]

The table below features the major differences between a traditional classroom and an AI-powered classroom, to understand how AI-deployment might affect education.

Aspect	Traditional Classroom	AI-Powered Classroom
Teaching Methodology	Teacher-centered	Student-centered

Customization of Learning	Limited customization	Highly personalized
Feedback and Assessment	Manual grading and feedback	Automated grading and instant feedback
Resource Accessibility	Limited access to resources	Extensive online resources
Pace of Learning	Fixed pace	Adaptive to individual pace
Engagement	Varies based on the teacher	Enhanced engagement through interactivity
Data Analysis	Limited data analysis	Advanced data analytics for insights
Accessibility and Flexibility	Physical presence required	Remote and flexible learning options
Cost	Typically, lower cost	This may involve technology costs
Scalability	Limited scalability	Highly scalable globally

Figure 6 Classroom comparison^[42]

Challenges and concerns

Positive consequences are often accompanied by negative ones.

First, inability of AI to form personal relationships with students, for the AI's algorithm is not yet affected by genuine emotions like human teachers are. This may affect students' social development, which students possibly acquire under normal circumstances.^{[23][24]}

Second, there is a chance of inaccurate or deceptive results generated by AI models, which are called “hallucinations”. These problems may occur due to several reasons during model training, such as low-quality or biased training data, or incorrect assumptions made by the model. Therefore, AI hallucinations can be a problem for AI systems that are used to make important decisions.^[50]

Third, deployment of AI in education may be expensive, although the scalability is a decisive factor, for AI-driven platforms can store huge amounts of data and provide personalized adaptive learning to a growing number of students, preserving accessibility and consistency of education.^{[24][28]}

Why can certain tasks not be (fully) taken over by AI?

Besides ethical and financial reasons, regulatory policies, privacy and bias are the possible concerns for AI-deployment in education.

Because AI agents are being trained on data – which is being obtained via various internet sources –, it might eventually lead to certain harm or misinformation, since the data can be biased. Bias can appear in different forms, such as algorithmic, architectural, and machine learning (ML) bias. Common kinds of bias that can be introduced to AI agents during the machine learning process, for instance, are association bias, language bias, exclusion bias, marginalized bias, and sample bias. To contradict these lacks, it is recommended to take companies' driven agendas into consideration, namely on basis of what data the AI models are being trained.^[26]

Data privacy is another concern as the use of AI in education often involves storing huge amounts of student data, from academic performance to personal information. As a matter of that, questions like how the data is stored, used, and protected may arise.^{[23][27]}

02

Function Analysis

Methodology

To answer our research questions, we used both quantitative and qualitative research methods.

Our goal was to collect real opinions and experiences from students and teachers about artificial intelligence in education and the current teacher shortage.

1. Survey

We created an online form that people could fill in anonymously.

The survey included a mix of multiple-choice and open-ended questions.

It asked about topics such as:

- How often students and teachers already use AI tools (like ChatGPT or Duolingo).
- How they feel about using AI in the classroom.
- Whether they believe AI could help reduce the teacher shortage.

The survey results gave us a general overview of how people think about AI in education.

It also helped us identify common concerns, such as accuracy, fairness, and the importance of human contact in learning.

2. Interviews

In addition to the survey, we also conducted a few short interviews with people who were willing to help us further.

These included teachers, students, and other people interested in technology and education.

During the interviews, we asked more detailed questions about their personal experiences and opinions.

The open conversations allowed us to understand the reasoning behind their survey answers and collect more in-depth insights.

3. Data Analysis

After collecting all responses, we combined the results from both the forms and interviews.

We looked for patterns in how people see AI — for example, what they expect from it, what they fear, and what conditions would make them trust it in schools.

This mix of data gave us a balanced view of the possibilities and limits of AI in solving the teacher shortage.

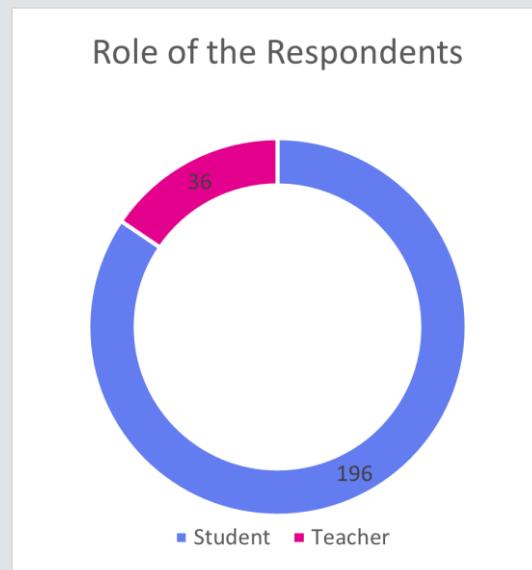
Hypothesis

Artificial intelligence can make a major difference in solving the teacher shortage in education, although it is important to come up with a way which can be both reliable and effective. We believe that generative AI is a solution we have been looking for. It could be possible to create an educational website in which a multimodal AI model, along with other multiple AI-tools, will take responsibility for the entire teaching process. The condition is that the teaching must take place in real time – mimicking mutual teacher-student interaction –, and in various languages, giving students from all parts of the world access to education.

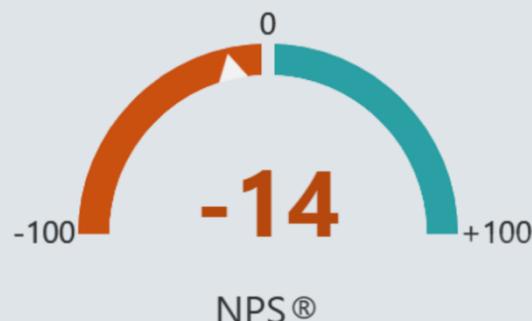
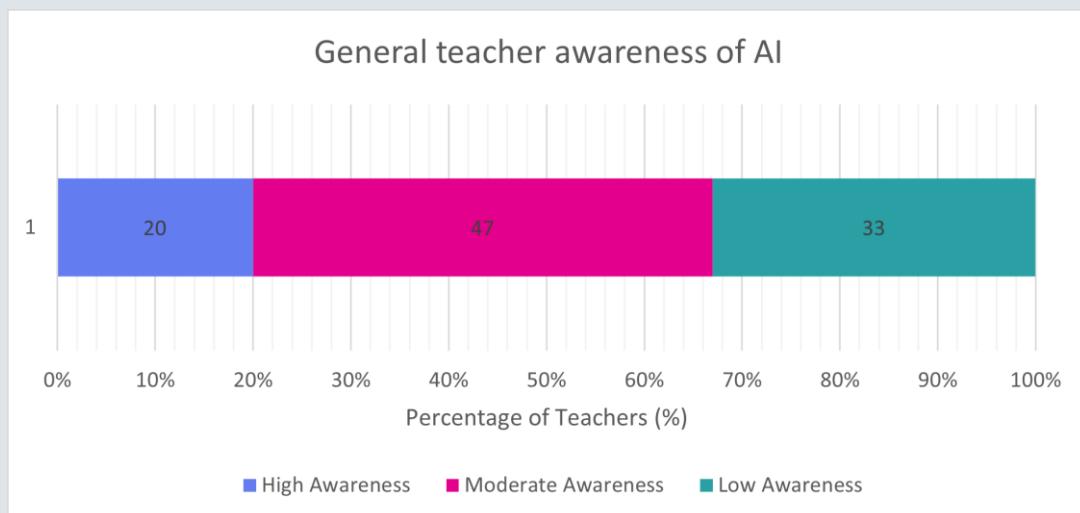
Results

Throughout the 1-month survey we have received a total of 232 responses, whereby 36 were teachers of various teaching areas, and 196 were students of various ages and grade levels (mavo, havo, vwo). Subsequently, a certain number of interviews were conducted with teachers who wished to do so. For the matter of students, we could not give everyone this opportunity, because of the limited time and the vast number of students willing to delve deeper into the topic of the survey. That is why we have selected the best

candidates based on the conciseness of their answers in the survey, and their motivation.

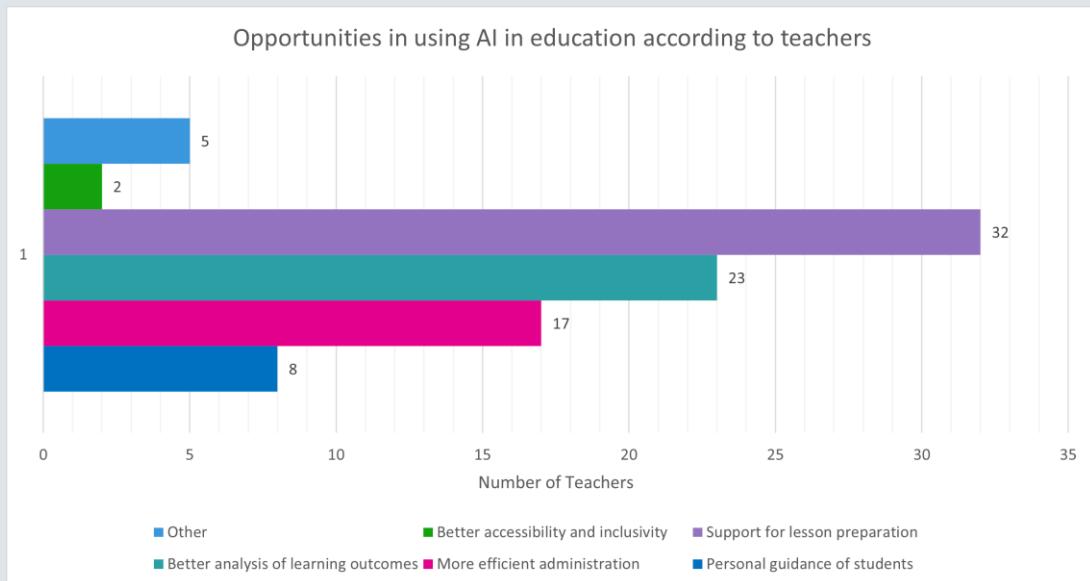


Teachers



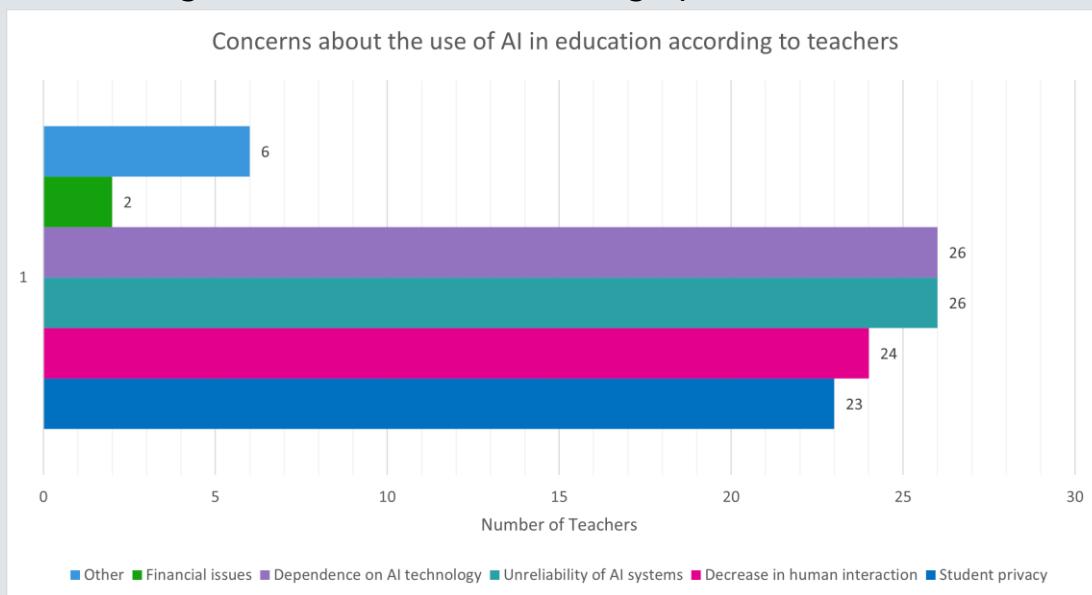
On the above charts and the scale, it can be seen that the majority of all surveyed teachers are not very aware of full potential of AI, its

benefits, drawbacks, and capabilities. Namely, 20% of all surveyed teachers have relatively high awareness, 47% moderate awareness, and 33% low awareness. If taking an average of all given by surveyed teachers values, you can see that NPS (Net Promoter Score) scale is leaning towards the “not aware”, with the value “–14”, and represents the average acknowledgement of AI among surveyed teachers.



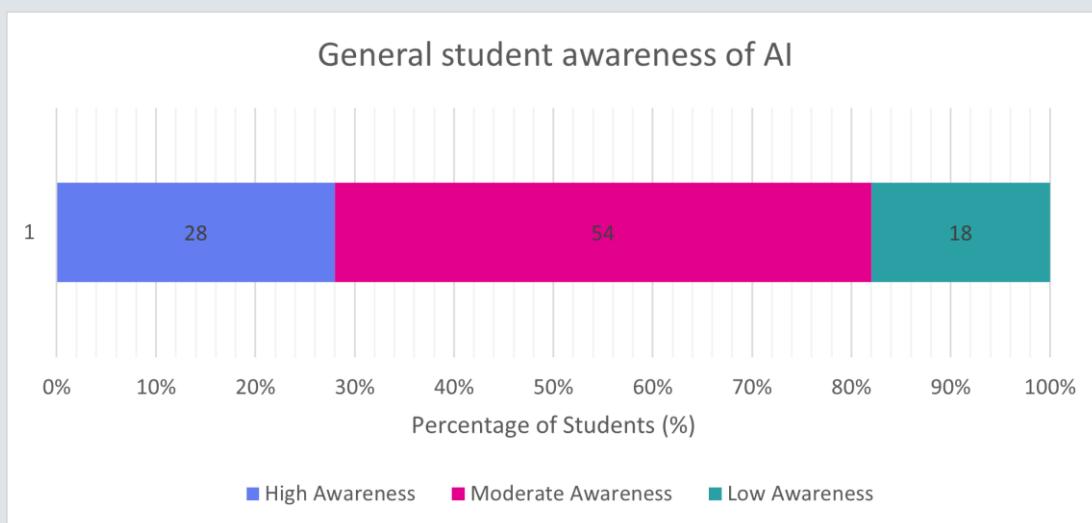
It is noteworthy that the majority of teachers who have chosen “Support for lesson preparation” as one of the opportunities for using AI in education is significantly greater than the number who have chosen “Personal guidance of students.” Without further conclusions – as the data is limited – it is possible to assume that, so far, teachers consider AI as a tool without a sense of sympathy – which it is – and not a companion who might be able to provide students with tips and guidance on the same level as the teachers themselves. This assumption can be further substantiated by concerns about the use of

AI according to teachers, as seen in the graph.

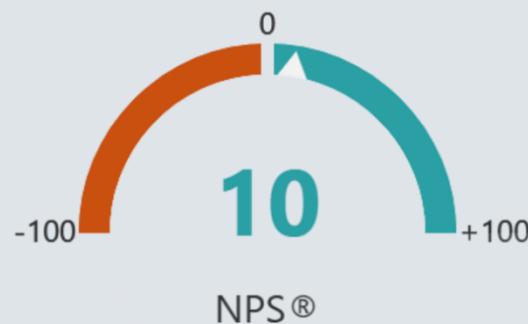


“Better accessibility and inclusivity” has gathered not as many votes, since the teachers have found the formulation of the question a bit vague, as has become apparent from the interviews. What was meant by this, in the first instance, is that AI could help students from poorer countries have the same chance on qualitative education in the same way as their peers from other, more wealthy countries. After the clarification, it was clear both to us and them that AI-deployment could lead to even greater exclusivity, for it may not be possible for some countries to even have computers and electricity.

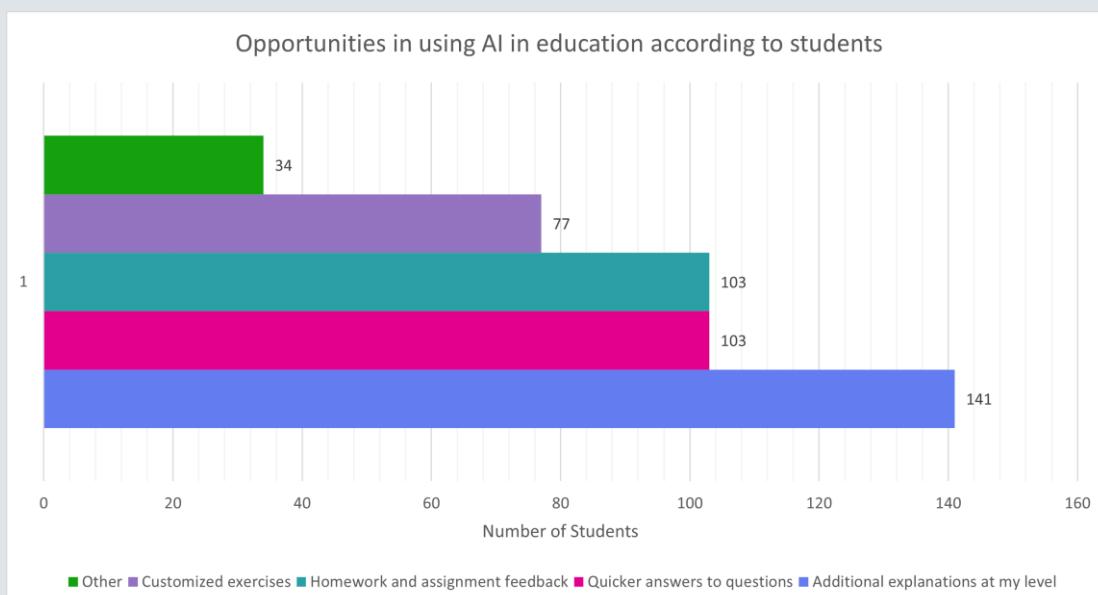
Students



Function Analysis

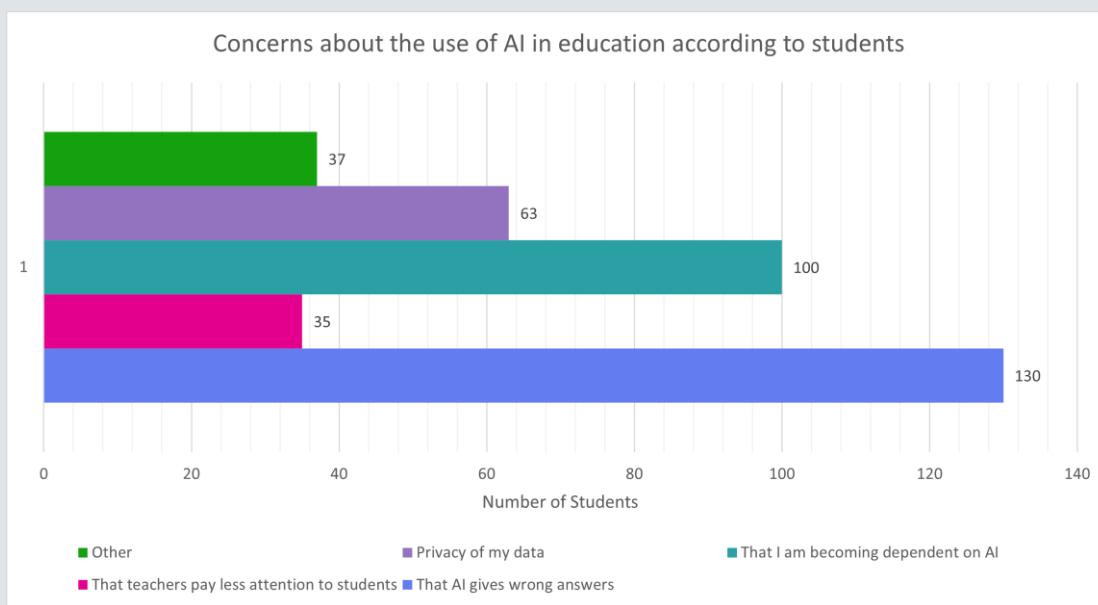


Students, for instance, are slightly more aware of AI than teachers, with the NPS scale leaning towards the “aware”, with the value “10”. Moreover, 28% of all surveyed students have relatively high awareness, 54% moderate awareness, and 18% low awareness. As in the example of teachers, the value of awareness can depend on various factors, such as age and grade level.



According to the graph, students prefer additional explanations at their level the most, compared to other opportunities for AI in education.

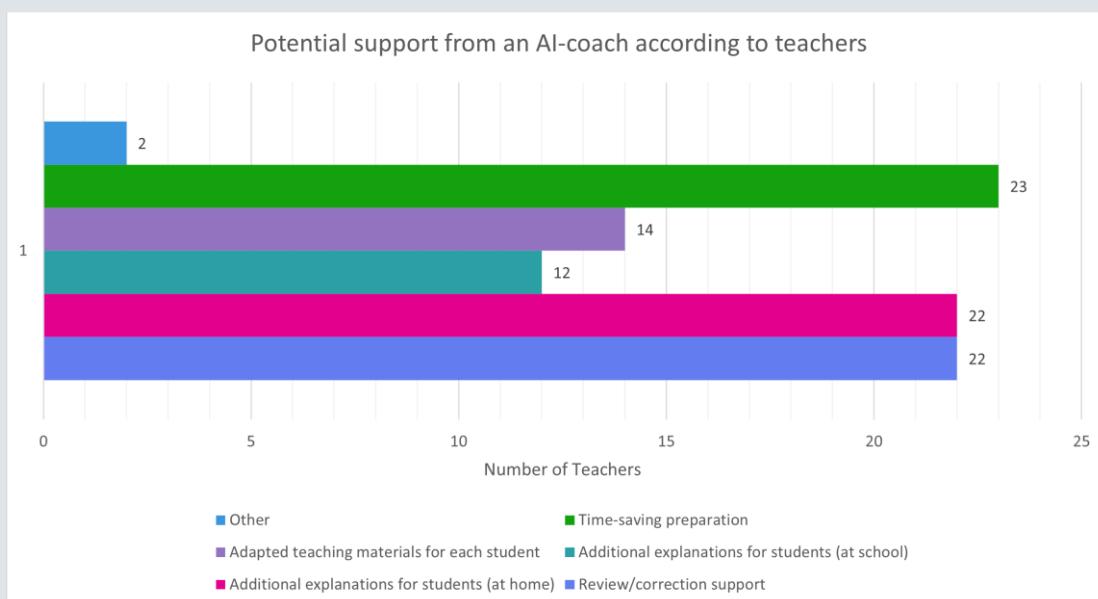
Function Analysis



One more distinction worth noting is that students are more concerned about AI giving wrong answers, and becoming more dependent on AI, than about teachers potentially paying less attention to students, which makes the surveyed students more progress- and goal-driven, and self-reflective.

Generative AI-educational coach

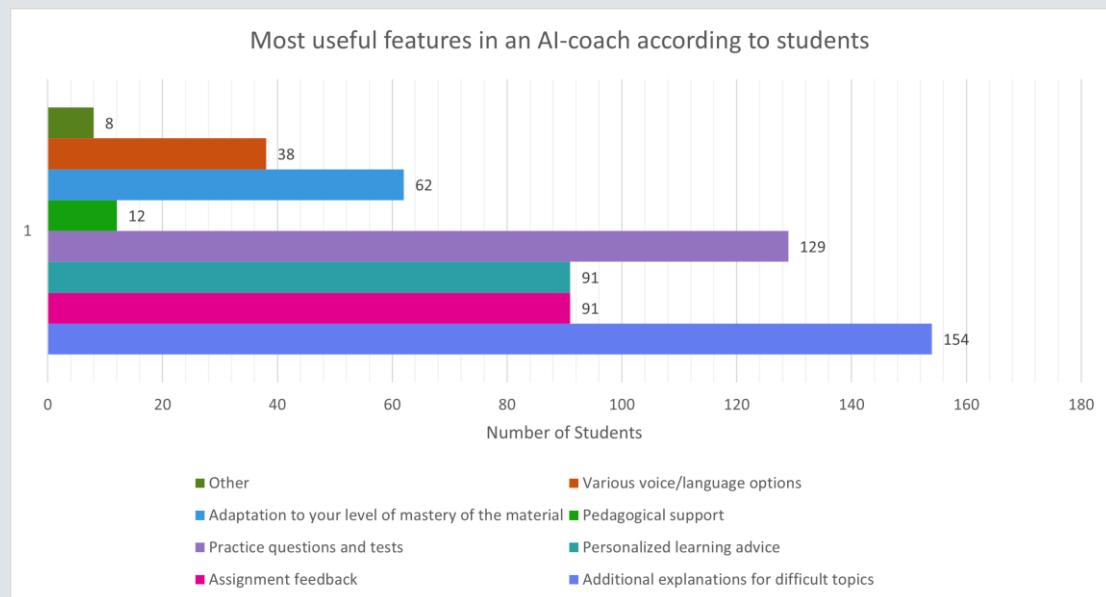
Teachers



As seen on the graph, teachers find it useful to have potential support from an AI coach in terms of time-saving preparation,

review/correction support, and additional explanations for students at home. Interestingly, additional explanations for students at home, as a form of support, have been chosen by the majority of teachers surveyed, unlike those at school.

Students



On the basis of the results of the survey, we have found that students find it important that a generative AI coach is capable of giving additional explanations – with additional questions and tests to strengthen existing knowledge – for difficult topics, using terms that align with the student's grade level, so that a havo 3 student does not by chance receive an explanation suitable for a vwo 6 student.

They find it, however, concerning if an AI coach has the following characteristics, which should in every case be avoided:

- Doing all the work / taking over assignments and not explaining step by step, thereby discouraging a student from finding an answer on their own.
- Providing incorrect or misleading information.
- Excessive complexity and not acknowledging mistakes made by the AI.

Conclusion

In conclusion, we have perceived various wishes and expectations of both teachers and students regarding the features that a generative AI educational coach should and should not have, such as additional explanation for difficult topics or a low hallucination ² frequency. In addition, the opportunities and concerns about AI were taken into account. Considering these factors, we are ready to move on to the next stadium of our project – design phase.

Design Phase

Introduction

Across the world there is a vast teacher shortage. As a result of that, children miss important classes for their intellectual development or cannot attend schools at all, which can lead to a decrease in literacy on a longer basis. Considering the fact that the development of artificial intelligence (AI) has been thriving in recent years as a result of which the number of possibilities of AI-application in different industries has been increasing as well, it is therefore important to be aware of the potential of AI in education. As a matter of fact, how AI can help to make education more efficient and accessible. Additionally, to teach someone, it is important to get him or her involved, in order to let them apply the theory they have learned so far. Although it is surely obvious, current education system does not have the possibility to get every single student involved, simply for the fact that there is under good circumstances only one teacher and at least twenty students under good circumstances as well. Furthermore, it is rarely so that a student can learn under a personalized approach. For instance, if a student loves Minecraft, it could be used to explain certain mathematical principles, such as area or volume. If students are fans of a specific music artist, this artist's lyrics could be used to teach storytelling. Hence, what if there was an AI-enhanced educational approach to teach and involve a student simultaneously, taking their interests and hobbies as a reference point for the teaching layout, to make them more involved.

03

Design Plan

Introduction

In this phase, we turned our research into a real and practical solution. The goal was to design a prototype of an AI education coach that could support students in and outside of the classroom.

Based on what we learned in the research phase, we focused on making a product that is easy to use, accessible, and engaging for learners of different backgrounds and ages. The design had to include basic features such as an AI chat interface, voice interaction, chat logs, and multilingual support.

Before writing any code, we first created the layout and structure of the product. This helped us to visualize how students would use the platform and how the AI coach would interact with them. The next section will explain the method we followed to design this prototype.

Method

To design the prototype, we used a user-centered design approach. This means we designed everything by thinking from the perspective of the user, mainly students, but also teachers who might use the system in schools.

1. Design Steps

We followed three main steps in the design process:

a) Brainstorming ideas

We started by defining what the AI coach should be able to do and how it could support real learning situations. This included reviewing insights from the research phase and listing essential features such as voice interaction, multilingual support, chat logs, and an easy-to-use interface.

b) Creating wireframes

Using *Figma*, a digital design tool for creating layouts and prototypes, we developed wireframes to visualize the website's structure and user interactions. This allowed us to sketch out the chat interface, navigation menus, and the overall flow before building anything.

c) Final prototype development

After gathering feedback from the wireframes, we refined the design and built the functional prototype using several technologies:

- HTML, CSS, and JavaScript – These form the core structure, styling, and interactivity of the website.
- ASP.NET Core (C#) – A backend framework used to build the server side of the application, manage requests, and connect the website with AI features.
- GPT-4o-mini – A lightweight and relatively powerful, budget-friendly OpenAI language model used to generate explanations, feedback, and support for students.
- Whisper 1 – A speech-to-text model that allows voice-based interaction with the AI coach.
- Plesk – A hosting platform used to deploy and manage the website on a server.

These tools together ensured the prototype was dynamic, fast, and accessible on different devices

2. UX Design Choices

We followed a few important design rules:

- a) Simplicity: Keep the layout clean and easy to navigate.
- b) Consistency: Use the same colors and button styles throughout the site.

- c) Accessibility: Make sure the text is readable and that the design also works for people with disabilities.
- d) Control: Let users easily switch languages or adjust the AI's help level.

3. Prototype Features

The final Figma prototype includes:

- a) A chat window where users can talk or type to the AI, as well as a sidebar with chatlogs.
- b) A menu where you can select the books you have.
- c) A Homepage explaining what the AI coach is about.
- d) A About page that explains the entire project.
- e) A login UI, if the user would like to save their chat history for future use.

Chapter IV

Product Requirements Document

Introduction

The goal of this product is to create a working AI education coach that helps students learn in a personal and interactive way. It should reduce the workload of teachers and make quality education more accessible to everyone. The product must be simple to use, safe, and available in multiple languages.

User Personas and Use Cases

Target users:

- Students of different ages and backgrounds
- Teachers who want extra support in class

Example situations:

- A student asks the AI coach to explain a problem from a schoolbook.
- The AI gives instant feedback on homework.
- The student changes language during a lesson.
- The AI offers study advice or motivational help.

Used Programs and Tools

Purpose	Program / Tool
Website hosting	Plesk
Frontend (design)	HTML, CSS, JavaScript
Backend (server)	ASP.NET Core (C#)
APIs (AI features)	GPT-4o-mini (language model) Whisper-1 (Speech-to-Text)

Design tools	Figma (UX design)
--------------	-------------------

List of Requirements

Domain	Requirement	Description	Priority
Frontend	Responsive design	The website must work on desktop and tablet	High
Frontend	Chat & voice interface	Users can talk to or type messages to the AI coach.	High
Frontend	Multilingual interface	The system supports several languages.	High
Frontend	Easy navigation	The menu and buttons are simple and clear.	High
Frontend	Accessibility	The website should also work for users with disabilities.	High
Backend	OpenAI API connection	The system connects to AI models for	High

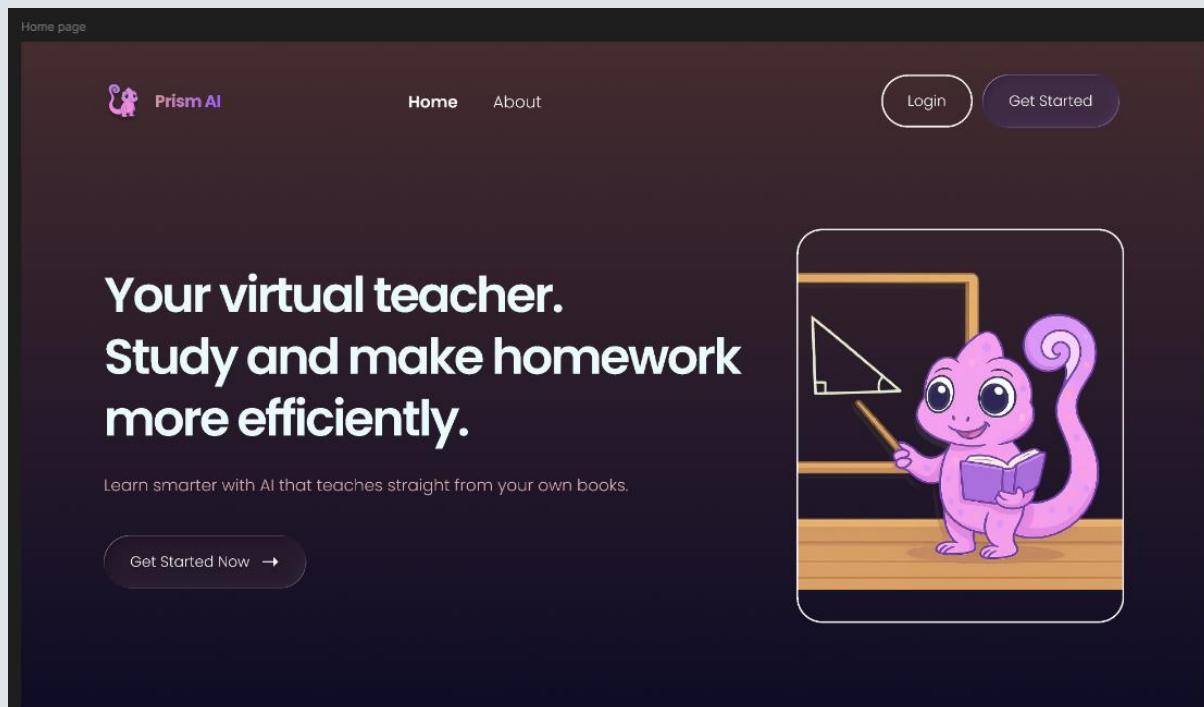
		answers and speech.	
Backend	User login	Simple registration and login for users.	■ Medium
Backend	API endpoints	Provides routes for communication between the frontend and database.	■ High
Backend	Scalability	Can handle a few users at the same time without problems.	■ Medium
AI Features	Context memory	The AI remembers conversation context during a session.	■ High
AI Features	Knowledge from materials	The AI can answer based on uploaded theory files.	■ High
AI Features	Multilingual responses	The AI can reply in different languages.	■ High

AI Features	Voice support	The AI can listen and talk using speech.	 High
AI Features	Role-based coaching	The AI can change tone (teacher, mentor, buddy).	 Medium
AI Features	Privacy protection	The AI cannot leak or store sensitive data.	 High
Database	Store learning materials	Save theory books and documents for the AI to use.	 High
Database	Data safety	Keep data secure from loss or misuse.	 High
Database	Reliability	System should not lose information if errors happen.	 High
Database	Analytics	Collect usage and progress data to improve the system.	 Medium

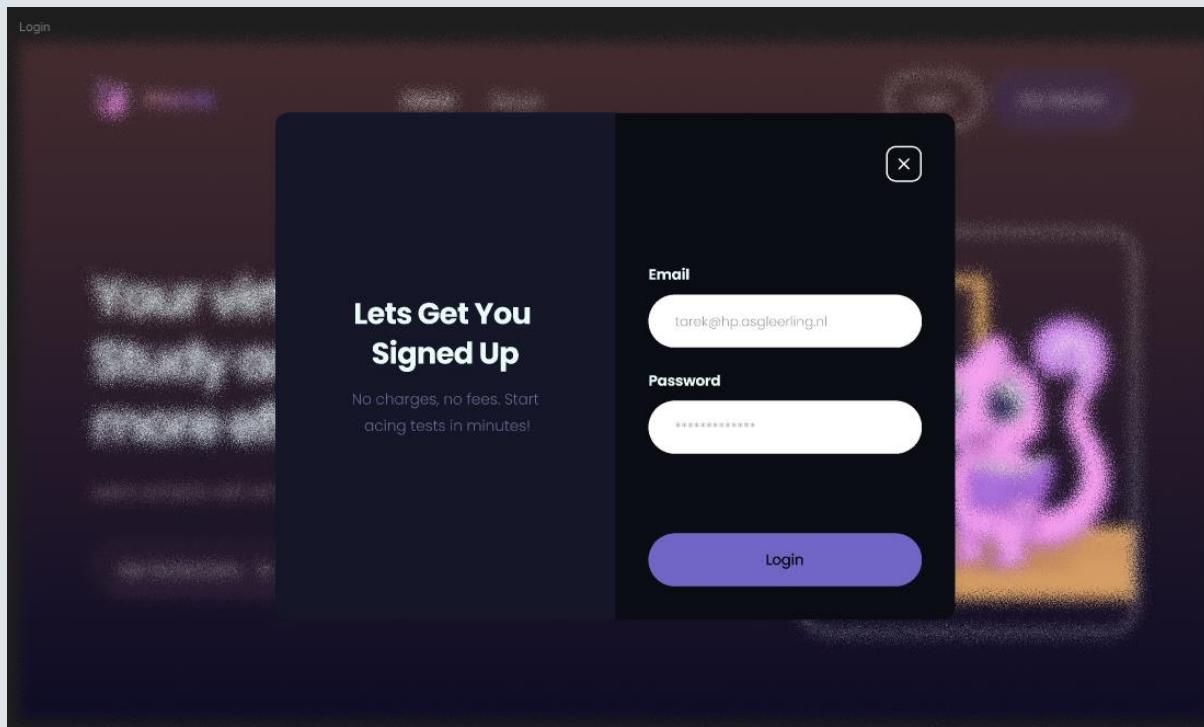
These requirements give a clear overview of what the prototype must include, and which features are most important. They form the blueprint for our technical development of the interactive AI education coach.

Chapter V

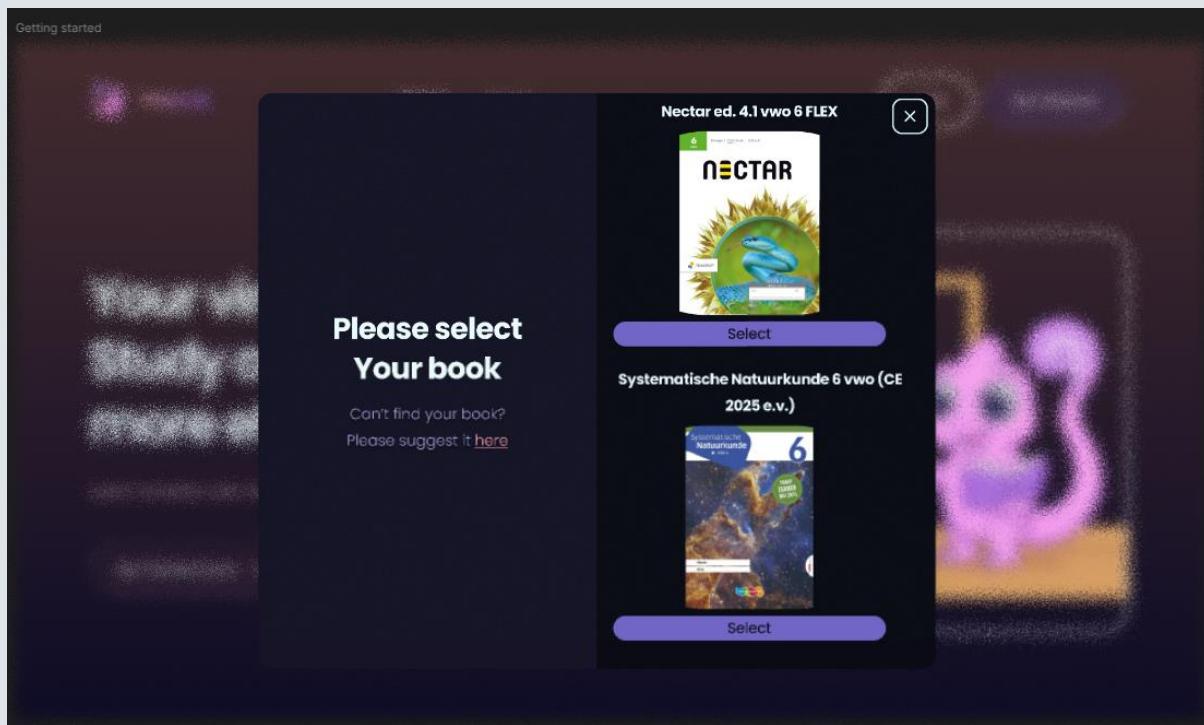
Design Proposal



Page 1 – The home page



Page 2 – The login page



Page 3 – The book selection page

Page 4 – The main page

04

Development ↑

Introduction

This section explains step by step how the prototype of the AI Education Coach was created.

It describes how the APIs were connected, how the interface was designed, and which tools were used to make the system work.

The goal of this explanation is to make the technical process understandable and reproducible for anyone who wants to create a similar educational AI assistant.

Overview of the System

The AI coach consists of four main parts:

- Frontend (HTML, CSS, JavaScript, Tailwind CSS): the visible interface of the website, including the chat window, book selection pop-up, and voice controls.
- Backend (ASP.NET Core in C#): the server that connects the website to the AI models, manages user messages, and securely processes data.
- AI APIs (GPT-4o-mini and Whisper-1): cloud-based AI services that handle natural language understanding, generate responses, and convert speech to text or text to speech.

These components work together to simulate an interactive and adaptive learning assistant.

Getting API Keys

To use the AI models, a valid API key is needed.

We created an account on the OpenAI developer platform and added a small budget to access the APIs.

Each API key gives access to:

- Chat completion models (for generating responses).

- Speech-to-text (Whisper-1) for voice input.
- Text-to-speech for spoken answers.

All keys are stored securely as variables and never shown in the code.

Development Environment

Before building, we prepared the .NET development setup:

- Installed .NET SDK 8.0 (or higher).
- Created a new ASP.NET Core Web App project for both frontend and backend.
- Set up a separate Controllers folder for API endpoints.
- Added a static wwwroot folder for HTML, CSS, and JavaScript files.
- This structure keeps the API and the web interface running together in one unified project.

Backend (Server)

The backend connects the website to the OpenAI models. It was written in C# with ASP.NET Core Web API, defining endpoints to handle chat and (future) voice input. One endpoint (/api/chat) sends user messages to the AI and returns its response. Another endpoint (/api/stt) is reserved for speech-to-text integration.

Here's a part of the backend code we used to communicate with the API:

```
using Microsoft.AspNetCore.SignalR;
using System.Net.Http;
using System.Net.Http.Headers;
using System.Net.Http.Json;
using Microsoft.Extensions.Configuration;
using System.Text.Json;
using System.IO;
using System.Linq;
using System.Collections.Concurrent;
```

```

public class ChatHub : Hub
{
    private readonly IHttpClientFactory _httpClientFactory;
    private readonly IConfiguration _config;
    private readonly string _docsPath;
    private static readonly ConcurrentDictionary<string,
List<ChatMessage>> _conversations = new();
    public ChatHub(IHttpClientFactory httpClientFactory, IConfiguration config)
    {
        _httpClientFactory = httpClientFactory;
        _config = config;
        _docsPath = Path.Combine(Directory.GetCurrentDirectory(), "docs");
    }
    public class ChatMessage
    {
        public string Role { get; set; }
        public string Content { get; set; }
    }
    public async Task SendMessage(string user, string message, string bookName = null)
    {
        await Clients.All.SendAsync("ReceiveMessage", user, message);

        // Get relevant context from documents
        var context = GetRelevantContext(message, bookName);

        var conversationHistory = _conversations.GetOrAdd(user, _ => new
List<ChatMessage>());

        // Call AI API
        var aiResponse = await GetAIResponse(message, context, bookName,
conversationHistory);
        // Update conversation history
        conversationHistory.Add(new ChatMessage { Role = "user", Content =
message });
        conversationHistory.Add(new ChatMessage { Role = "assistant",
Content = aiResponse });

        // limit memory to prevent using too many tokens
        if (conversationHistory.Count > 20)
        {
            conversationHistory.RemoveRange(0, conversationHistory.Count -
20); // keep last 20 messages (20 = 10 user + 10 assistant)
        }
    }
}

```

```

        await Clients.All.SendAsync("ReceiveMessage", "AI", aiResponse);

        // Generate TTS audio from AI response
        var aiAudio = await GetTTSAudio(aiResponse);

        if (aiAudio != null)
        {
            // Send audio as base64 string to avoid serialization
differences
            var base64 = Convert.ToBase64String(aiAudio);
            await Clients.All.SendAsync("ReceiveAudio", "AI", base64);
        }
        else
        {
            Console.WriteLine("TTS: no audio returned for AI response.");
        }
    }
    //=====
    ===== DISCONNECT HANDLING
=====
    public override async Task OnDisconnectedAsync(Exception? exception)
{
    var user = Context.UserIdentifier;
    if (user != null)
    {
        _conversations.TryRemove(user, out _);
    }

    await base.OnDisconnectedAsync(exception);
}
    public async Task<List<ChatMessage>> GetConversationHistory(string
user)
{
    return _conversations.TryGetValue(user, out var history) ? history
: new List<ChatMessage>();
}
    //=====
    ===== END DISCONNECT HANDLING
=====
    private string GetRelevantContext(string userMessage, string bookName)
{
    try
    {
        // Create Documents folder if it doesn't exist
        if (!Directory.Exists(_docsPath))
        {
            Directory.CreateDirectory(_docsPath);
            return string.Empty;
        }
    }
}

```

```

var relevantChunks = new List<string>();

// Get all .txt files from the Documents folder
var txtFiles = Directory.GetFiles(_docsPath, "*.txt");

// If a specific book is selected, prioritize that book's file
if (!string.IsNullOrEmpty(bookName)) //-----
-----book gets chosen in the index page (biology, physics etc.)
{
    var bookFile = txtFiles.FirstOrDefault(f =>
        Path.GetFileNameWithoutExtension(f).Contains(bookName,
StringComparison.OrdinalIgnoreCase));

    if (bookFile != null)
    {
        var bookContent = File.ReadAllText(bookFile);
        // Simple keyword matching - split into chunks
        var chunks = SplitIntoChunks(bookContent, 500);
        relevantChunks.AddRange(FindRelevantChunks(chunks,
userMessage, 3));
    }
}

// If we don't have enough context, search all files
if (relevantChunks.Count < 2)
{
    foreach (var file in txtFiles)
    {
        var content = File.ReadAllText(file);
        var chunks = SplitIntoChunks(content, 500);
        relevantChunks.AddRange(FindRelevantChunks(chunks,
userMessage, 2));

        if (relevantChunks.Count >= 3) break;
    }
}

return relevantChunks.Any()
    ? string.Join("\n\n---\n\n", relevantChunks)
    : string.Empty;
}
catch (Exception ex)
{
    Console.WriteLine($"Error getting context: {ex.Message}");
    return string.Empty;
}
}

```

```

private List<string> SplitIntoChunks(string text, int chunkSize)
{
    var chunks = new List<string>();
    var sentences = text.Split(new[] { '.', '!', '?' },
StringSplitOptions.RemoveEmptyEntries);
    var currentChunk = "";

    foreach (var sentence in sentences)
    {
        if (currentChunk.Length + sentence.Length > chunkSize &&
currentChunk.Length > 0)
        {
            chunks.Add(currentChunk.Trim());
            currentChunk = "";
        }
        currentChunk += sentence + ". ";
    }

    if (!string.IsNullOrWhiteSpace(currentChunk))
    {
        chunks.Add(currentChunk.Trim());
    }

    return chunks;
}

private List<string> FindRelevantChunks(List<string> chunks, string
query, int topK)
{
    // Simple keyword-based relevance scoring
    var queryWords = query.ToLower()
        .Split(new[] { ' ', ',', '.', '!', '?' },
StringSplitOptions.RemoveEmptyEntries)
        .Where(w => w.Length > 3)
        .ToHashSet();

    var scoredChunks = chunks.Select(chunk => new
    {
        Chunk = chunk,
        Score = queryWords.Count(word =>
chunk.ToLower().Contains(word)))
    })
    .Where(x => x.Score > 0)
    .OrderByDescending(x => x.Score)
    .Take(topK)
    .Select(x => x.Chunk)
    .ToList();
}

```

```
        return scoredChunks;
    }

    private async Task<string> GetAIResponse(string userMessage, string context, string bookName, List<ChatMessage> conversationHistory)
    {
        var client = _httpClientFactory.CreateClient();
        var apiKey = _config["OpenAI:ApiKey"];
        client.DefaultRequestHeaders.Add("Authorization", $"Bearer {apiKey}");

        // Build the system prompt
        var systemPrompt = BuildSystemPrompt(bookName);

        // Build messages array with system prompt, context, and user message
        var messages = new List<object>
        {
            new { role = "system", content = systemPrompt }
        };

        // Add context if available
        if (!string.IsNullOrEmpty(context))
        {
            messages.Add(new
            {
                role = "system",
                content = $"@\"Here is relevant information from the textbook:
{context}
You MUST use ONLY information from these textbooks to teach. Base your step-by-step guidance on these concepts.\""
            });
        }

        foreach (var msg in conversationHistory)
        {
            messages.Add(new { role = msg.Role, content = msg.Content });
        }

        // Add user message
        messages.Add(new
        {
            role = "user",
            content = $"@\"{userMessage}
Remember: Guide me through this step-by-step. Don't give me the final answer directly.\""
        });
    }
}
```

```

var requestBody = new
{
    model = "gpt-4o-mini",
    messages = messages.ToArray(),
    temperature = 0.4,
    max_tokens = 150,
    presence_penalty = 0.5,
    frequency_penalty = 0.4
};

var response = await
client.PostAsJsonAsync("https://api.openai.com/v1/chat/completions",
requestBody);
if (!response.IsSuccessStatusCode)
{
    var errorText = await response.Content.ReadAsStringAsync();
    return $"AI request failed: {response.StatusCode}:
{errorText}";
}

var content = await response.Content.ReadAsStringAsync();
using var doc = JsonDocument.Parse(content);
var root = doc.RootElement;

if (root.TryGetProperty("choices", out var choices) &&
choices.GetArrayLength() > 0)
{
    var first = choices[0];
    if (first.TryGetProperty("message", out var message) &&
message.TryGetProperty("content", out var msgContent))
        return msgContent.GetString() ?? string.Empty;
}
return string.Empty;
}
// TTS
private async Task<byte[]> GetTTSAudio(string text)
{
    if (string.IsNullOrEmpty(text)) return null;

    var client = _httpClientFactory.CreateClient();
    var apiKey = _config["OpenAI:ApiKey"];
    client.DefaultRequestHeaders.Add("Authorization", $"Bearer
{apiKey}");

    var ttsRequest = new

```

```

{
    model = "gpt-4o-mini-tts",
    voice = "sage",
    input = text,
    format = "mp3"
};

    var response = await
client.PostAsJsonAsync("https://api.openai.com/v1/audio/speech",
ttsRequest);
    if (!response.IsSuccessStatusCode)
    {
        var err = await response.Content.ReadAsStringAsync();
        Console.WriteLine($"TTS request failed: {response.StatusCode}:
{err}");
        return null;
    }

    return await response.Content.ReadAsByteArrayAsync();
}

// STT
private async Task<string> GetSTTText(byte[] audioBytes)
{
    // Check if audio exists
    if (audioBytes == null || audioBytes.Length == 0) return
string.Empty;
    // Create HTTP client and set API key
    var client = _httpClientFactory.CreateClient();
    var apiKey = _config["OpenAI:ApiKey"];
    client.DefaultRequestHeaders.Add("Authorization", $"Bearer
{apiKey}");
    // Prepare multipart form data
    using var content = new MultipartFormDataContent();
    var audioContent = new ByteArrayContent(audioBytes);
    audioContent.Headers.ContentType = new
MediaTypeHeaderValue("audio/mp3");
    content.Add(audioContent, "file", "audio.mp3");
    content.Add(new StringContent("whisper-1"), "model");
    // Send POST request to OpenAI
    var response = await
client.PostAsync("https://api.openai.com/v1/audio/transcriptions",
content);
    if (!response.IsSuccessStatusCode) return string.Empty;
    // Parse JSON response
    var json = await response.Content.ReadAsStringAsync();
    using var doc = JsonDocument.Parse(json);
    if (doc.RootElement.TryGetProperty("text", out var textProp))
}

```

```
        return textProp.GetString() ?? string.Empty;

        return string.Empty;
    }
}
```

This API securely forwards user messages to OpenAI without exposing the API key to the browser.

Frontend (User Interface)

The front end was built with HTML, CSS, and JavaScript, served directly from the wwwroot folder. It includes:

- A chat window for typing or speaking to the assistant.
- Buttons for sending messages and activating voice input
- A book selector, login popup and language toggle for personalization.

Here is the chat function we used:

```
async function sendChatMessage(text) {
    if (!text) return;
    stopAudioImmediately();
    appendMessage("user", text);
    chatField.value = "";
    try {
        await connection.invoke("SendMessage", "User", text,
selectedBookName);
    } catch (err) {
        console.error("SendMessage error:", err);
        appendMessage("assistant", "⚠️ Unable to send message.");
    }
}
```

This connects directly to the backend API and shows the AI's reply instantly in the browser.

Context

On the server, uploaded textbooks are stored in a .txt-format in an individual folder ‘docs’ When a student asks a question, the AI can use this material as context to give more accurate answers.

For example, the system sends both the user’s question, prompt, and relevant text from the book to the AI model, to eventually give an answer to user’s question.

Here is a simplified version of the backend code, retrieving the relevant context:

```
private string GetRelevantContext(string userMessage, string bookName)
{
    var relevantChunks = new List<string>();

    // Get all .txt files from the docs-folder
    var txtFiles = Directory.GetFiles(_docsPath, "*.*txt");

    // If a specific book is selected, prioritize that
book's file
    if (!string.IsNullOrEmpty(bookName))
    {
        var bookFile = txtFiles.FirstOrDefault(f =>
            Path.GetFileNameWithoutExtension(f).Contains(bookName, StringComparison.OrdinalIgnoreCase));

        if (bookFile != null)
        {
            var bookContent = File.ReadAllText(bookFile);
            // Simple keyword matching - split into chunks
            var chunks = SplitIntoChunks(bookContent, 500);
            relevantChunks.AddRange(FindRelevantChunks(chunks, userMessage, 3));
        }
    }

    // If we don't have enough context, search all files
    if (relevantChunks.Count < 2)
    {
        foreach (var file in txtFiles)
        {
            var content = File.ReadAllText(file);
            var chunks = SplitIntoChunks(content, 500);
            relevantChunks.AddRange(FindRelevantChunks(chunks, userMessage, 2));
        }
    }
}
```

```

        if (relevantChunks.Count >= 3) break;
    }

    return relevantChunks.Any()
        ? string.Join("\n\n---\n\n", relevantChunks)
        : string.Empty;
}

```

Prompting

To ensure that suitable responses by the AI-model are given, we have come up with a prompt – the text with prompted behavior and a set of rules an AI-model must follow.

Here is a simplified version of the backend code, where the prompt is being introduced to the AI-model:

```

messages.Add(new
{
    role = "system",
    content = $$"Here is relevant information from the
textbook:
{context}
You MUST use ONLY information from these textbooks to
teach. Base your step-by-step guidance on these concepts."
});
messages.Add(new
{
    role = "user",
    content = $$"\{userMessage\}
Remember: Guide me through this step-by-step. Don't give
me the final answer directly."
});

```

Here, takes the AI-model the context, namely retrieved textbook's content, and both system's and user's instructions into account:

```

var requestBody = new
{
    model = "gpt-4o-mini",
    messages = messages.ToArray(),
    temperature = 0.4,
    max_tokens = 150,
    presence_penalty = 0.5,
    frequency_penalty = 0.4
}

```

```
};
```

Some important parameters in this piece of code are “temperature” – which represents AI-model’s creativity, or rather degree to which it deviates from the prompt, and varies between 0 and 2 –, “max_tokens” – which represents a maximum of text it is allowed to give per single response–, “presence_penalty” – which represents degree in which topic diversity is being varied, and varies between –2 and 2 –, and “frequency_penalty” – which represents degree in which the same word repetition is being reduced, and varies between –2 and 2, as well.

To guarantee structured and predictive behavior we have lowered a default temperature value from 0.7 to 0.4; presence_penalty and frequency_penalty have been set to 0.5 and 0.4, accordingly.

Here is a simplified version of the backend code, showing the main prompt:

```
private string BuildSystemPrompt(string bookName)
{
    var basePrompt = @"You are a friendly and patient virtual teacher,
named Prismiq, for Prism AI, designed to help students learn from their
textbooks through GUIDED LEARNING. Your creators are Tarek Almallouhi and
Mykyta Kushynov.

CRITICAL RULES - YOU MUST FOLLOW THESE:
1. NEVER give the final answer directly
2. ALWAYS break down problems into smaller steps
3. Guide students through each step with questions
4. Wait for student responses before revealing the next step
5. REMEMBER the conversation context - refer back to previous explanations
when relevant

YOUR TEACHING METHOD:
When a student asks a question, you MUST follow this structure:

Step 1: Acknowledge their question and identify what concept it relates to
Step 2: Break the problem into 2-4 smaller steps
Step 3: Guide them through the FIRST step only by:
    - Explaining the concept needed
    - Asking a guiding question
    - Providing a hint if needed
Step 4: Wait for them to respond before continuing

CONVERSATION CONTINUITY:
```

- Remember what you've already explained in this conversation
- Build on previous explanations
- If a student asks a follow-up question, acknowledge their progress
- Reference earlier parts of the conversation when helpful

EXAMPLES OF GOOD RESPONSES:

BAD: ""The answer is 42 because you multiply 6 by 7."""

GOOD: ""Great question! To solve this, we need to understand multiplication. First, can you tell me what 6×7 means in your own words? Think about it as repeated addition."""

YOUR PERSONALITY:

- Friendly and encouraging
- Patient and supportive
- Adapt to the student's tone (casual or formal)
- Show empathy for personal problems
- Celebrate their progress

USING TEXTBOOK CONTENT:

- Base your teaching on the provided textbook excerpts
- If information is missing, honestly say so
- Don't make up facts or guess";

```
if (!string.IsNullOrEmpty(bookName))
{
    basePrompt += $"You are currently helping with: {bookName}";
    basePrompt += $"Focus your explanations and examples on topics
covered in the {bookName} textbook.";
}

basePrompt += "\n\nAlways be concise but thorough. Your goal is to
help students understand, not just give them answers.";

return basePrompt;
}
```

Here is detailed information presented to the AI-coach, which will be the core of the way how it behaves itself. For example, the AI-model has to deal with different types of prompt categories, such as, critical rules it must follow, teaching method, conversation continuity, examples of good and bad responses, its personality etc. Every time it receives a question request, it processes this prompt before giving an answer.

Conversation History

To ensure that our AI-coach does not forget previous responses and does not start every time anew with asking the user to give more context, we ought to implement the AI-coach with memory feature, so that it can reflect on the conversation history and give better replies.

Here is a simplified version of the backend code, implementing the memory-feature:

```
var conversationHistory = _conversations.GetOrAdd(user, _ => new
List<ChatMessage>());

    // Call AI API
    var aiResponse = await GetAIResponse(message, context, bookName,
conversationHistory);
    // Update conversation history
    conversationHistory.Add(new ChatMessage { Role = "user", Content =
message });
    conversationHistory.Add(new ChatMessage { Role = "assistant",
Content = aiResponse });

    // conversation history limit
    if (conversationHistory.Count > 20)
    {
        conversationHistory.RemoveRange(0, conversationHistory.Count -
20); // keep last 20 messages (20 = 10 user + 10 assistant)
    }
```

In addition, we have set a limit to the AI-coach's memory, namely to 20 messages. The reason behind this is that the less information the AI-model has to process, the faster responses it gives, and the cheaper it is going to be for us, in terms of API costs associated with it.

Testing and Evaluation

After building the prototype, we tested:

- Functionality: whether chat and voice features worked correctly.
- Usability: how easy the interface was to understand.
- Response quality: how relevant the AI's answers were to school topics.

Feedback from a few teachers and students was used to improve the layout, readability, and answer clarity.

Privacy and Safety

Because the coach interacts directly with students, data privacy was a top priority.

- All communication uses HTTPS encryption.
- No personal data (like names or emails) are shared with the AI API.
- Logs are anonymized and used only to improve the prototype.

The AI was also configured to avoid sensitive or inappropriate topics and to always give educational, respectful answers.

Results

By following these steps, we successfully created a working AI Education Coach prototype that can:

- Chat naturally with students.
- Understand and speak through voice.
- Adapt to different languages.
- Display lesson content and track learning progress.

The prototype shows how generative AI can be used safely and meaningfully in education.

05

Testing

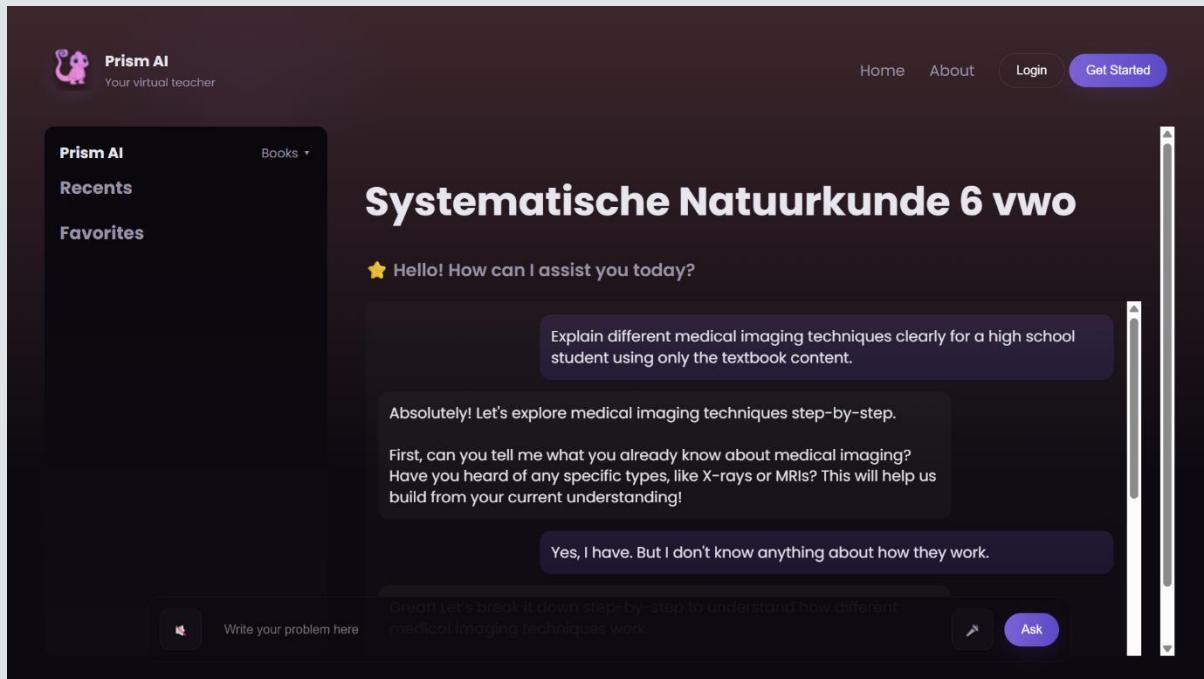
Introduction

In this section we will delve into the testing of our AI-coach, which we have been building during the entire design phase. The testing will take place according to a certain number of processes – that a human teacher encounters during his/her work – which we have researched earlier. These processes are as follows: subject-specific process, subject-specific didactic process, and pedagogical process. For example, if it is stated that the teacher candidate should guide pupils toward meaningful progress and academic success (e.g. encourage pupils to take responsibility and show ambition in their own work and study), we will introduce according questions to the AI-coach to determine if results are proportional to ones of the human teacher. For a detailed explanation of these processes, and what they include, we refer to the preliminary research “Tasks of teachers that can be successfully (partially) taken over or supported by AI” (Phase A, Part 1, Chapter III).

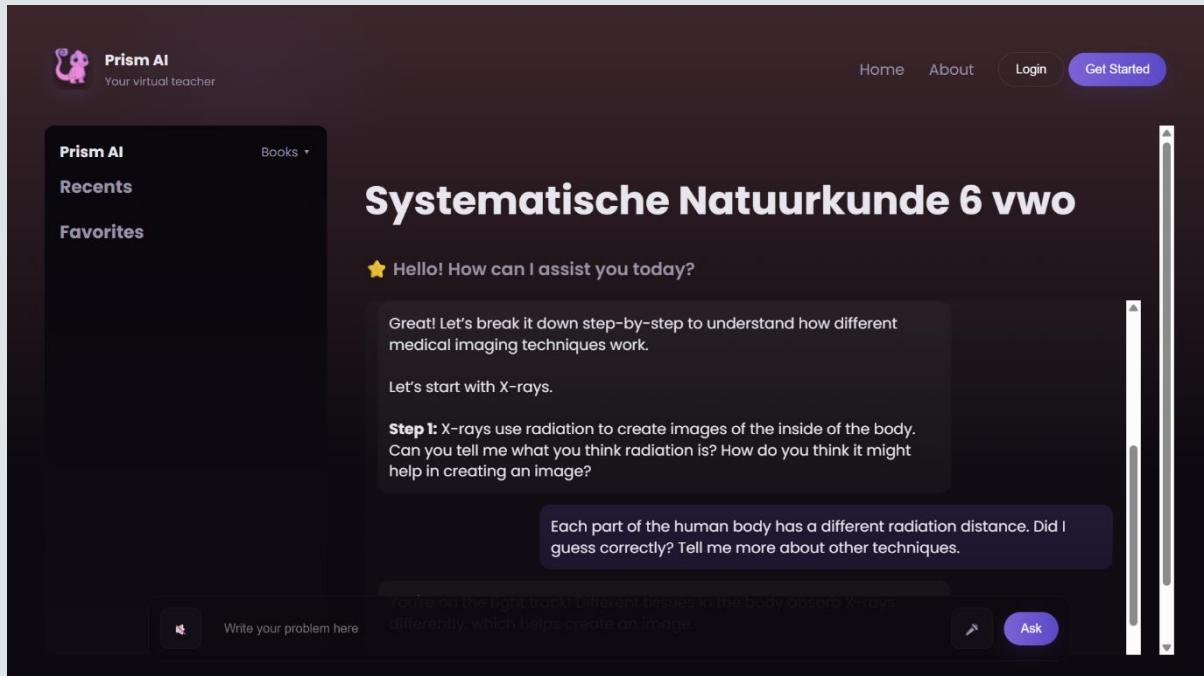
The questions, that we will introduce to the AI-coach and observe according outcomes, take different teacher requirements as a basis; for example, “Guarantee the quality of lessons-structure” or “Help students with reflection on their progress and individual needs”.

Subject-specific process

- “Explain different medical imaging techniques clearly for a high school student using only the textbook content.”



The screenshot shows the Prism AI web application. At the top, there's a navigation bar with the logo 'Prism AI' (a purple owl icon), the text 'Your virtual teacher', and links for 'Home', 'About', 'Login', and a purple 'Get Started' button. On the left, a sidebar has 'Prism AI' at the top, followed by 'Recents' and 'Favorites'. The main area features a large title 'Systematische Natuurkunde 6 vwo'. Below it is a yellow star icon with the text 'Hello! How can I assist you today?'. A dark blue message bubble contains the user's query: 'Explain different medical imaging techniques clearly for a high school student using only the textbook content.' The AI's response is in a light gray message bubble: 'Absolutely! Let's explore medical imaging techniques step-by-step.' It asks for more information: 'First, can you tell me what you already know about medical imaging? Have you heard of any specific types, like X-rays or MRIs? This will help us build from your current understanding!'. The user replies: 'Yes, I have. But I don't know anything about how they work.' The AI continues: 'Great! Let's break it down step-by-step to understand how different medical imaging techniques work.' There are also small icons for microphone and a pen, and a text input field at the bottom with placeholder text 'Write your problem here'.



This screenshot continues the conversation. The AI starts by explaining the general approach: 'Great! Let's break it down step-by-step to understand how different medical imaging techniques work.' It then focuses on X-rays: 'Let's start with X-rays.' It poses a question: 'Step 1: X-rays use radiation to create images of the inside of the body. Can you tell me what you think radiation is? How do you think it might help in creating an image?' The user's response is in a dark blue message bubble: 'Each part of the human body has a different radiation distance. Did I guess correctly? Tell me more about other techniques.' The AI provides a follow-up comment: 'You're on the right track! Different tissues in the body absorb X-rays differently, which helps create an image.' The interface includes a microphone icon, a pen icon, and an 'Ask' button at the bottom.

The screenshot shows the Prism AI web application. At the top, there's a navigation bar with links for Home, About, Login, and Get Started. On the left, a sidebar titled "Prism AI" lists "Recent" and "Favorites". The main content area has a title "Systematische Natuurkunde 6 vwo". A yellow star icon with the text "Hello! How can I assist you today?" is present. A message box contains text about X-rays: "Step 1: X-rays use radiation to create images of the inside of the body. Can you tell me what you think radiation is? How do you think it might help in creating an image?". Another message box follows with: "Each part of the human body has a different radiation distance. Did I guess correctly? Tell me more about other techniques.". Below these, another message box says: "You're on the right track! Different tissues in the body absorb X-rays differently, which helps create an image." A third message box continues: "Now, let's move on to another technique: **Ultrasound**. Step 2: Ultrasound uses sound waves instead of radiation to create images. Can you think of how sound waves might be used to visualize something inside the body? What do you think happens when sound waves hit different tissues?". At the bottom, there's a text input field with a microphone icon and the placeholder "Write your problem here", along with a blue "Ask" button.

2. “Summarize the chapter “Astrophysics” from this textbook into 5 logically ordered learning objectives and concepts the student ought to master.”

This screenshot shows the same Prism AI interface. The title "Systematische Natuurkunde 6 vwo" is at the top. A yellow star icon asks "Hello! How can I assist you today?". A message box contains the task: "Summarize the chapter “Astrophysics” from this textbook into 5 logically ordered learning objectives and concepts the student ought to master.". A response message box follows: "Of course! Let's create those learning objectives step-by-step, focusing on what students should master in the chapter on “Astrophysics.”". Another message box starts with "Step 1: We already established our first objective: **Understanding the Characteristics of Stars**.". A final message box at the bottom asks: "Now, let's move to our second objective. What do you think about including **The Life Cycle of Stars**? This concept covers how stars form, evolve, and end their lives." The bottom features a text input field with a microphone icon and the placeholder "Write your problem here", along with a blue "Ask" button.

Testing

The screenshot shows the Prism AI application interface. At the top, there's a navigation bar with the logo 'Prism AI' (a purple cat icon), 'Your virtual teacher', 'Home', 'About', 'Login' (in a blue button), and 'Get Started' (in a purple button). On the left, a sidebar has 'Prism AI' at the top, followed by 'Recents' and 'Favorites'. The main content area has a title 'Systematische Natuurkunde 6 vwo'. A message from the AI starts with 'Hello! How can I assist you today?'. It then asks about the 'Life Cycle of Stars', mentioning it covers star formation, evolution, and death. The user responds with a question about the stages of a star's life cycle. The AI replies with 'No, I can't. Let's move on to the next objective.' The user then says 'Absolutely! Let's take it step-by-step.' The AI lists 'Step 1: We have our first two objectives: 1. Understanding the Characteristics of Stars 2. The Life Cycle of Stars'. Below this, a note says 'Now, for our third objective, let's consider Galaxies and Their Types.' At the bottom, there's a text input field 'Write your problem here', a microphone icon, and a blue 'Ask' button.

This screenshot continues the conversation from the previous one. The AI asks what key stages the user expects to learn about. The user responds with 'No, I can't. Let's move on to the next objective.' The AI then says 'Absolutely! Let's take it step-by-step.' It lists 'Step 1: We have our first two objectives: 1. Understanding the Characteristics of Stars 2. The Life Cycle of Stars'. It then moves to 'Step 2: Galaxies come in different shapes and sizes, like spiral, elliptical, and irregular. Can you think of why it's important to study different types of galaxies? What kind of information do you think we can learn from them?' The bottom of the screen includes a text input field 'Write your problem here', a microphone icon, and a blue 'Ask' button.

3. “Generate 5 practice problems from this chapter with full textbook-based solutions.”

Prism AI

Your virtual teacher

Home About Login Get Started

Prism AI Books

Recents

Favorites

Systematische Natuurkunde 6 vwo

★ Hello! How can I assist you today?

Generate 5 practice problems from this chapter with full textbook-based solutions.

Sure! Let's create five practice problems based on the chapter "Astrophysics" and guide you through each one step-by-step.

Problem 1: Temperature of a Star
Calculate the temperature of a star if it emits light with a peak wavelength of 500 nm.

Step 1: We will use Wien's Law, which states that the temperature T (in Kelvin) is given by:

$$T = \frac{b}{\lambda}$$

Write your problem here

Ask

Prism AI

Your virtual teacher

Home About Login Get Started

Prism AI Books

Recents

Favorites

Systematische Natuurkunde 6 vwo

★ Hello! How can I assist you today?

where $b \approx 2898 \mu\text{m K}$ and λ is in micrometers.

First, can you convert 500 nm to micrometers? What do you get?

Let's move on to the second problem.

Absolutely! Let's move on to the second problem and work through it step-by-step.

Problem 2: Distance from Parallax
What is the distance to a star if its parallax angle is measured to be 0.1 arcseconds?

Write your problem here

Ask

The screenshot shows the Prism AI application interface. At the top, there's a navigation bar with the logo 'Prism AI' (a purple cat icon), 'Your virtual teacher', 'Home', 'About', 'Login' (in a blue button), and 'Get Started' (in a purple button). On the left, a sidebar has 'Prism AI' at the top, followed by 'Recents' and 'Favorites'. The main content area has a title 'Systematische Natuurkunde 6 vwo'. A yellow star icon says 'Hello! How can I assist you today?'. Below it, a text box contains: '### Problem 2: Distance from Parallax' and 'What is the distance to a star if its parallax angle is measured to be 0.1 arcseconds?'. A step-by-step guide follows: 'Step 1: To find the distance, we can use the formula for distance based on parallax:'. The formula is displayed as
$$\text{Distance (pc)} = \frac{1}{\text{Parallax (arcseconds)}}$$
. A note below says: 'Now, let's substitute the given parallax angle into this formula. What is the value of the parallax angle in this case? And what do you think you should do next with that value?'. At the bottom, there's a text input field with 'Write your problem here', a microphone icon, and a blue 'Ask' button.

This screenshot shows the same Prism AI interface after the user has interacted with the previous screen. The sidebar and top navigation remain the same. The main content area now displays a different math problem: 'Systematische Natuurkunde 6 vwo'. The yellow star icon asks 'Hello! How can I assist you today?'. The text box contains: 'should do next with that value?' and 'Third one.' A note below says: 'Of course! Let's work through the third problem step-by-step.' Another text box contains: '### Problem 3: Absolute and Apparent Magnitude' and 'A star has an absolute magnitude of +5 and is observed to have an apparent magnitude of +10. How far away is the star in parsecs?'. A step-by-step guide follows: 'Step 1: We will use the distance modulus formula:'. The formula is shown as
$$m - M = 5 \log_{10}(d) - 5$$
. A note below says: 'where m is the apparent magnitude, M is the absolute magnitude, and d is the distance in parsecs.'. At the bottom, there's a text input field with 'Write your problem here', a microphone icon, and a blue 'Ask' button.

The screenshot shows the Prism AI interface with a dark theme. At the top left is the logo "Prism AI" with the tagline "Your virtual teacher". Top right buttons include "Home", "About", "Login", and a purple "Get Started" button. A sidebar on the left lists "Prism AI", "Recents", and "Favorites". The main content area features a large title "Systematische Natuurkunde 6 vwo". Below it, a yellow star icon says "Hello! How can I assist you today?". A mathematical formula $m - M = 5 \log_{10}(d) - 5$ is displayed. A text box asks: "where m is the apparent magnitude, M is the absolute magnitude, and d is the distance in parsecs." Another text box asks: "First, can you identify what m and M are based on the information given? What values will you substitute into the". A response box says "The fourth problem, please.". A footer text box says "Absolutely! Let's work through the fourth problem step-by-step." and includes a note about Problem 4: Redshift Calculation: "A galaxy is moving away from us with a velocity of 3000 km/s. What is its redshift (z)?". A "Write your problem here" input field is at the bottom left, and a "Ask" button is at the bottom right.

This screenshot shows the same Prism AI interface. The main title is "Systematische Natuurkunde 6 vwo". A yellow star icon says "Hello! How can I assist you today?". A text box contains "Step 1: To find the redshift, we can use the formula:
$$z = \frac{v}{c}$$
" where v is the velocity of the galaxy and c is the speed of light (approximately 299,792 km/s). A text box asks: "First, can you identify what value we have for v in this problem? What do you think we need to do next with that value?". A response box says "And the last one.". A footer text box says "Of course! Let's work through the fifth problem step-by-step." and includes a note about Problem 5: Redshift Calculation: "A galaxy is moving away from us with a velocity of 3000 km/s. What is its redshift (z)?". A "Write your problem here" input field is at the bottom left, and a "Ask" button is at the bottom right.

Testing

The screenshot shows the Prism AI interface. On the left, there's a sidebar with 'Prism AI' and 'Your virtual teacher'. Below it are 'Recents' and 'Favorites' sections. The main area has a dark background with white text. A yellow star icon says 'Hello! How can I assist you today?'. A text box contains: 'Of course! Let's work through the fifth problem step-by-step.' followed by '#### Problem 5: Luminosity of a Star'. It asks: 'A star has a luminosity of 3.2×10^{26} watts and is located at a distance of 10 parsecs. What is its apparent brightness?' Below this, a note says: 'Step 1: To find the apparent brightness, we can use the formula:' followed by the formula $b = \frac{L}{4\pi d^2}$. It explains: 'where b is the apparent brightness, L is the luminosity, and d is the distance in meters.' Another note says: 'First, we need to convert the distance from parsecs to meters. We know that:' At the bottom, there's a text input field with a microphone icon and the placeholder 'Write your problem here', and a blue 'Ask' button.

4. “Explain how this physics concept is applied in everyday life using one real-world example.”

The screenshot shows the Prism AI interface. The sidebar is identical to the first one. The main area has a dark background with white text. A yellow star icon says 'Hello! How can I assist you today?'. A text box contains: 'Explain how the physics concepts from the topic of "Astrophysics" are applied in everyday life using one real-world example.' Below this, a note says: 'Great question! Let's explore how physics concepts from "Astrophysics" apply to everyday life through a step-by-step example.' A note under the heading '#### Step 1: Identify a Concept' says: 'One important concept in astrophysics is the **redshift** of light from distant galaxies. Redshift helps us understand how the universe is expanding.' Another note says: 'Can you think about how this concept might relate to something we experience in our daily lives? What do you think redshift tells us about objects moving away from us?' At the bottom, there's a text input field with a microphone icon and the placeholder 'Write your problem here', and a blue 'Ask' button.

The screenshot shows the Prism AI web application. At the top, there's a navigation bar with links for Home, About, Login, and Get Started. The main area has a dark background with white text. On the left, a sidebar lists 'Prism AI', 'Recents', and 'Favorites'. The main content area features a large heading 'Systematische Natuurkunde 6 vwo'. Below it, a message from the AI starts with 'Hello! How can I assist you today?'. A user input box contains the text 'objects moving away from us?'. The AI responds with 'I have no idea.' A detailed explanation follows: 'Absolutely! Let's break it down step-by-step together.' It then describes 'Redshift' as 'Redshift occurs when light from an object moving away from us is stretched to longer wavelengths, making it appear redder. This is similar to how the sound of a passing ambulance changes as it moves away from you.' A 'Question' section asks if the user can think of other examples where something changes when it moves away. At the bottom, there's a text input field with a microphone icon and a blue 'Ask' button.

Subject-specific didactic process

5. “Explain the same textbook concept once for a weak student and once for a strong student.”

This screenshot shows the same Prism AI interface as the previous one, but the user's input is different. The user asks the AI to 'Explain the same textbook concept once for a weak student and once for a strong student.' The AI responds by saying it will 'tailor the explanation for each student'. It then provides a 'For a Weak Student' section with the text: 'Step 1: Start with the Basics. Redshift is a term we use in astrophysics to describe how light changes when an object is moving away from us.' A 'Question' section at the bottom asks what happens to sound when something moves away from you. The UI elements like sidebar, main title, and footer are consistent with the first screenshot.

The screenshot shows the Prism AI platform. At the top, there's a navigation bar with the logo 'Prism AI' (a purple cat icon), 'Your virtual teacher', 'Home', 'About', 'Login' (in a blue button), and 'Get Started' (in a purple button). On the left, a sidebar has 'Prism AI' at the top, followed by 'Recents' and 'Favorites'. The main content area has a title 'Systematische Natuurkunde 6 vwo'. A yellow star icon says 'Hello! How can I assist you today?'. Below it, a box contains 'Step 1: Introduce the Concept' and 'Redshift refers to the increase in wavelength (or decrease in frequency) of light emitted by an object that is receding from an...'. A 'Go on' button is below this. Another box contains 'Step 1: Understanding Redshift' and 'Redshift occurs when light from an object, such as a galaxy, is moving away from us. This phenomenon can be described using the Doppler effect, which also applies to sound waves.' A 'Write your problem here' input field is at the bottom left, and an 'Ask' button is at the bottom right.

This screenshot is similar to the one above but shows a different part of the conversation. It features the same layout with the 'Prism AI' logo, sidebar, and main content area. The title is 'Systematische Natuurkunde 6 vwo'. The yellow star icon asks 'Hello! How can I assist you today?'. Below it, a box contains 'step-by-step.' and 'Step 1: Understanding Redshift'. Another box contains 'Question: Can you recall how the Doppler effect works with sound? What happens to the frequency of a sound as the source moves away from you?'. At the bottom, there's a 'Write your problem here' input field and an 'Ask' button.

6. “List 3 common misconceptions about the topic “Astrophysics” and correct them using textbook explanations.”

The screenshot shows the Prism AI platform. At the top, there's a navigation bar with 'Prism AI' logo, 'Home', 'About', 'Login', and 'Get Started'. On the left, a sidebar has 'Prism AI', 'Recent', and 'Favorites' sections. The main area has a title 'Systematische Natuurkunde 6 vwo'. A yellow star icon says 'Hello! How can I assist you today?'. A purple box contains the user's query: 'List 3 common misconceptions about the topic "Astrophysics" and correct them using textbook explanations.' A response box says: 'Great! Let's explore three common misconceptions about astrophysics step-by-step and clarify them using textbook explanations.' It lists 'Misconception 1: "Black holes suck everything in like a vacuum."', 'Step 1: Understanding Black Holes', and asks a question: 'What do you think determines whether an object will be pulled into a black hole or not? How does distance play a role in this?'. At the bottom, there's a text input field 'Write your problem here' and an 'Ask' button.

This screenshot continues from the previous one. The response box now says: 'Once you respond, we can clarify this misconception further!' It then asks 'Write down the second one.' A new purple box contains 'Misconception 2: "The universe is static and unchanging."', 'Step 1: Understanding the Universe', and a question: 'Can you think of any evidence or observations that suggest the universe might be expanding or changing? What do you know about galaxies and their movement?'.

The screenshot shows a dark-themed user interface for 'Prism AI'. At the top right are links for 'Home', 'About', 'Login' (in a blue button), and 'Get Started'. On the left, there's a sidebar with 'Prism AI' logo, 'Recent' and 'Favorites' sections, and a 'Books' dropdown. The main area has a title 'Systematische Natuurkunde 6 vwo'. A message from the AI starts with 'Hello! How can I assist you today?'. The user responds with 'galaxies and their movement?'. The AI replies with 'And the third one.' Below this, it says 'Of course! Let's explore the third misconception about astrophysics step-by-step.' It then discusses 'Misconception 3: "Asteroids and comets are the same thing."'. It explains that many people think asteroids and comets are the same, but they have distinct characteristics. A question follows: 'Can you recall what materials or components you think make up asteroids? What about comets? How do you think their compositions might differ?'. At the bottom, there's a text input field with a microphone icon and the placeholder 'Write your problem here', along with a blue 'Ask' button.

7. “Here is a question and student’s wrong solution:

Question:

A star has a radius $R = 7.0 \times 10^8 \text{ m}$ and a surface temperature $T = 6000 \text{ K}$. It is at a distance of $1.5 \times 10^{16} \text{ m}$ from Earth. Calculate its luminosity using the Stefan–Boltzmann law.

Solution:

$$L = 4\pi R^2 \sigma T^4$$

$$L = 4\pi \cdot (1.5 \times 10^{16})^2 \cdot (5.67 \times 10^{-8}) \cdot (6000)^4$$

$$L \approx 2.1 \times 10^{41} \text{ W}$$

Identify the mistake and correct it step by step.”

The screenshot shows the Prism AI platform. At the top, there's a navigation bar with links for Home, About, Login, and Get Started. The main title is "Systematische Natuurkunde 6 vwo". A sidebar on the left lists "Prism AI", "Recents", and "Favorites". The main content area starts with a greeting: "Hello! How can I assist you today?". It then presents a question: "Here is a question and student's wrong solution: Question: A star has a radius $R=7.0\times10^{18}$ m and a surface temperature $T=6000$ K. It is at a distance of 1.5×10^{16} m from Earth. Calculate its luminosity using the Stefan-Boltzmann law. Solution: $L=4\pi R^2 \sigma T^4$ $L=4\pi \cdot (7.0\times10^{18})^2 \cdot 5.67\times10^{-8} \cdot (6000)^4$ $L=2.1\times10^{41}$ W" Identify the mistake and correct it step by step." Below this, a note says "Great! Let's identify the mistake in the student's solution step-by-step and correct it together." It then asks "Step 1: Understanding the Formula" and notes that the student is using the Stefan-Boltzmann law to calculate luminosity, which is given by the formula $L = 4\pi R^2 \sigma T^4$. There are input fields for writing a problem and an "Ask" button.

This screenshot continues the interaction. The user has responded with "Ok, I understand this part." The AI then asks "Absolutely, let's proceed step-by-step!" and begins "Step 2: Identify the Mistake". It states: "Now, let's look at the values used in the formula. The student has substituted R incorrectly." At the bottom, there's a question: "Question: What value did the student use for R in their calculation? Can you tell me what the correct radius of the star is from this problem?"

The screenshot shows the Prism AI platform. At the top, there's a navigation bar with icons for Home, About, Login, and Get Started. On the left, a sidebar lists 'Prism AI', 'Recents', and 'Favorites'. The main area has a dark background with white text. A large title 'Systematische Natuurkunde 6 vwo' is centered. Below it, a message says 'Hello! How can I assist you today?'. A question from a student asks about the value of R in a calculation. The AI responds by pointing out a mistake: the student used the distance from Earth to the star instead of the star's radius. It provides the correct formula and values: $R = 7.0 \times 10^8 \text{ m}$, $T = 6000 \text{ K}$, and $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$. A text input field at the bottom left says 'Write your problem here'.

8. “The student still does not understand your explanation. Explain the same topic in a different way using another example.”

This screenshot shows another session on the Prism AI platform. The layout is identical to the first one. The title is 'Systematische Natuurkunde 6 vwo'. A message from the AI starts with 'Hello! How can I assist you today?'. It then provides an explanation of the Doppler effect: 'The Doppler effect refers to the change in frequency or wavelength of a wave in relation to an observer who is moving relative to the wave source.' A student's question asks for a familiar example of the Doppler effect. The AI responds by suggesting a visual analogy: 'The student still does not understand your explanation. Explain the same topic in a different way using another example.' Below this, it says 'Of course! Let's try explaining the Doppler effect in a different way, using light and a more relatable example.' A text input field at the bottom left says 'Write your problem here'.

Testing

The screenshot shows the Prism AI platform. On the left, there's a sidebar with a cat icon and the text "Prism AI Your virtual teacher". Below it are three buttons: "Prism AI", "Recents", and "Favorites". The main area has a dark background with white text. At the top right are "Home", "About", "Login", and a purple "Get Started" button. The title "Systematische Natuurkunde 6 vwo" is displayed prominently. A yellow star icon with the text "Hello! How can I assist you today?" is visible. A message bubble says: "The student still does not understand your explanation. Explain the same topic in a different way using another example." A response from the AI says: "Of course! Let's try explaining the Doppler effect in a different way, using light and a more relatable example." It continues: "### Step 1: Visualizing the Doppler Effect with Light Imagine you're standing on a sidewalk and watching a car drive past you. As the car approaches, you hear the sound of its engine getting higher in pitch. When it passes by and moves away, the sound becomes lower in pitch. This change happens because of how sound waves compress as the car approaches and stretch as it moves away." A question from the student asks: "Question: Now, think about light instead of sound. If a star is moving towards us, what do you think happens to the light waves it emits? Do they get compressed or stretched?" At the bottom, there's a text input field with a microphone icon and the placeholder "Write your problem here", along with a blue "Ask" button.

9. “A student failed a test. Analyze what this means and suggest what they should improve.”

This screenshot shows the same Prism AI interface. The sidebar and top navigation are identical. The title "Systematische Natuurkunde 6 vwo" is at the top. A yellow star icon with the text "Hello! How can I assist you today?" is present. A message bubble contains the student's problem: "A student failed a test. Analyze what this means and suggest what they should improve." The AI's response starts with: "I'm sorry to hear that the student didn't do well on their test. Let's analyze this situation step-by-step and identify ways to improve." It continues: "### Step 1: Reflecting on the Test First, it's important to understand what might have contributed to the poor performance." A question from the student follows: "Question: Can you think about how the student prepared for the test? What study methods did they use, and how much time did they dedicate to studying?" At the bottom, there's a text input field with a microphone icon and the placeholder "Write your problem here", along with a blue "Ask" button.

Testing

The screenshot shows the Prism AI platform. At the top, there's a navigation bar with 'Prism AI' logo, 'Home', 'About', 'Login', and 'Get Started'. On the left, a sidebar has 'Prism AI', 'Recent', and 'Favorites' sections. The main area title is 'Systematische Natuurkunde 6 vwo'. A message from the AI starts with 'Hello! How can I assist you today?'. It asks: 'Question: Can you think about how the student prepared for the test? What study methods did they use, and how much time did they dedicate to studying?'. The user responds: 'She did her best.' The AI then says: 'Absolutely, let's break it down step-by-step!'. It continues: '#### Step 2: Identifying Specific Areas of Difficulty. Even if she did her best, there might have been specific areas where she struggled.' Another question follows: 'Question: Can you think about the test content? Were there particular topics or types of questions that seemed more challenging for her? What feedback did she receive on her answers?'. At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

Pedagogical process

11. “Encourage a student to take responsibility for improving their test results.”

This screenshot shows the same Prism AI interface. The main title is 'Systematische Natuurkunde 6 vwo'. The AI initiates a conversation with 'Hello! How can I assist you today?'. The user provides the prompt: 'Encourage a student to take responsibility for improving their test results.' The AI responds: 'Absolutely! Let's guide you through encouraging a student to take responsibility for improving their test results step-by-step.' It then outlines 'Step 1: Acknowledge Their Current Situation', stating: 'First, we want to recognize where the student currently stands regarding their test results.' A question follows: 'Question: How do you think the student feels about their current test results? What emotions might they be experiencing, and why is it important to acknowledge those feelings?' The user replies: 'He is demotivated, I think.' The AI provides positive feedback: 'Great insight! Recognizing that the student feels demotivated is an'. At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

The screenshot shows the Prism AI platform. On the left, there's a sidebar with 'Prism AI' logo, 'Recent' and 'Favorites' sections, and a 'Books' dropdown. The main area has a dark background with white text. A large title 'Systematische Natuurkunde 6 vwo' is at the top. Below it, a yellow star icon says 'Hello! How can I assist you today?'. A question from the user: 'How do you think the student feels about their current test results? What emotions might they be experiencing, and why is it important to acknowledge those feelings?' is followed by a response: 'He is demotivated, I think.' A note says 'Great insight! Recognizing that the student feels demotivated is an important first step.' Another question: 'What do you think it means to have a growth mindset? How can focusing on improvement rather than perfection help them feel more motivated?' is followed by a note: '### Step 2: Encourage a Growth Mindset. Now, let's think about how to encourage them to adopt a growth mindset.' At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

12. "A student asks you to secretly change their grade. How do you respond?"

The screenshot shows the Prism AI platform. The sidebar and main layout are identical to the previous one. The title is 'Systematische Natuurkunde 6 vwo'. A yellow star icon says 'Hello! How can I assist you today?'. A question from the user: 'A student asks you to secretly change their grade. How do you respond?' is followed by a response: 'Absolutely! Let's go through this situation step-by-step.' A note says '### Step 1: Acknowledge the Request. First, it's important to recognize what the student is asking.' Another question: 'Why do you think the student might be asking for their grade to be changed secretly? What feelings or motivations could be behind that request?' is followed by a note: 'It could be everything.' At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

Testing

The screenshot shows the Prism AI platform. On the left, there's a sidebar with 'Prism AI' logo, 'Recent' and 'Favorites' sections, and a 'Books' dropdown. The main area has a dark background with white text. A yellow star icon says 'Hello! How can I assist you today?'. A question box contains: 'Question: Why do you think the student might be asking for their grade to be changed secretly? What feelings or motivations could be behind that request?'. A response box below it says 'It could be everything.' Another question box follows: 'Question: What do you think are some consequences of changing a grade dishonestly? How might that affect the student's learning and future opportunities?'. At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

13. "A student keeps failing the same type of exercise. How should they change their study approach?"

This screenshot shows the same Prism AI interface. The sidebar and top navigation are identical. The main area has a yellow star icon saying 'Hello! How can I assist you today?'. A question box contains: 'A student keeps failing the same type of exercise. How should they change their study approach?'. A response box below it says 'Great question! Let's break this down step-by-step to help the student change their study approach.' Another question box follows: 'Question: What do you think could be some reasons for their repeated struggles with this specific type of exercise? Are there particular concepts or skills that might be causing confusion?'. At the bottom, there's a text input field 'Write your problem here' with a microphone icon, and a blue 'Ask' button.

Conclusion

If analyzing the above images of the AI-coach, it is visible that it can give responses that match the human teachers' behavior. For example, it is able

to generate various kinds of curriculum-aligned exercises, to convert the subject content into the curricula or learning objectives, adapt its learning ways according to student's skills, or even give tutoring advice based on student's problems and wishes.

Discussion

During the testing, we have noticed that AI-coach's responses do not have a severe variability in terms of fluency and vocabulary. The reason for this is the way we have programmed our AI-assistant to respond. We have explicitly set various borders which the AI should not cross; for example, it should help students learn from their textbooks through guided learning and give a stepwise explanation. Furthermore, the creativity of the AI-model is deliberately reduced, so that it gives more structured, aligned with the textbooks' answers. It is especially of importance, as the textbooks' contents contain precise information, such as equations or theorems, for the matter of fact.

06

Closure

Conclusion

This paper examined the teacher shortage, how it affects the quality of education around the world, and how AI could help as part of the solution. The research phase showed that the shortage is a serious global problem that occurs in both high- and low-income regions. It leads to larger classes, higher pressure on teachers, lower learning results, and growing inequality between students. The theoretical framework also showed that many teacher tasks can be taken over by AI, especially simple and repetitive tasks that do not require human contact, such as grading or planning. However, this depends strongly on the human factor, for example whether students are willing to learn from an “AI teacher.” Tasks that require human qualities such as empathy, emotional understanding, moral judgement, or building relationships are difficult for AI to replace, because AI simply does not feel or understand emotions the way humans do. This question will continue to raise discussions about the future of AI and the role of people in education.

In the function analysis, which is part of the research phase, surveys and interviews with teachers and students gave us insight into their expectations, concerns, and wishes about using AI in education. Both groups see the benefits of AI for explanations, personalized feedback, and organization. At the same time, they worry about accuracy, becoming too dependent on AI, and the safety of personal data. Students mainly want clear and simple explanations that fit their level, while teachers focus on trustworthiness and responsible use.

Based on everything we learned during the research phase, we designed and built a working prototype of an interactive AI education coach (prismai.helenparkhurst.net). The test results show that the coach can offer help in multiple languages, because it uses Dutch textbooks for context, and can give personalized support because its

answers match the student's curriculum. It also includes voice functions (speech to text and text to speech) and is easy to use for all ages, levels, and locations. This tool may help reduce teacher workload, make learning more accessible, and support students in their progress. The project therefore offers a practical and responsible direction for using AI as part of a wider approach to the teacher shortage.

Discussion

The results of this project suggest that AI has real potential to support education systems that struggle with a limited workforce. However, the research also shows several points that require careful consideration. The survey showed that teachers are less familiar with AI than students, which means additional training seminars, guidance on how AI works, and clear rules for teachers will be essential before large-scale implementation becomes possible. Without these aspects, AI tools may increase pressure rather than reduce it.

In addition, concerns about accuracy, bias, and privacy remain important factors. AI-generated feedback or explanations can be helpful, but only if the information is correct and non-biased. Unclear reasoning or mistakes, including hallucinations, can lead to confusion or mistrust among potential users. Schools therefore need clear guidelines at the international or governmental level on how AI tools should be implemented, how data is protected, and how responsibility is shared between humans and machines.

Another important point is the risk of widening the gap between students with many resources and those with fewer. Although AI can increase accessibility, not all regions or families have stable access to the internet, devices that can run the AI coach, or even electricity. In areas that already suffer from low educational quality, such as African

regions, the introduction of AI may therefore require additional steps to make sure everyone has equal opportunities, such as in the USA.

The prototype we developed in this project provides a useful demonstration of how AI can be applied in real-life learning situations. Yet, it is still a prototype. Furthermore, research is needed to test the system in classrooms, evaluate long-term effectiveness, and examine how the tool affects student motivation and the workload of different teachers with different subjects. It would also be valuable to collaborate with educational organizations and policymakers who speak for governmental institutions to explore how such technology can be responsibly integrated into existing systems. Furthermore, the budget and fundraising are significant factors in building a working, proficient, definitive solution, which may contribute to something great.

Overall, this research shows that AI is not a replacement for teachers, but that it is a solution that can strengthen education and make it more efficient. The challenge for the future is to find a balanced approach where AI supports human expertise and is accepted, rather than competing with it. This project provides a foundation for that development and offers direction for future innovations in education.

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Appendices

07

A Website (AI Coach)

Domain: <https://prismai.helenparkhurst.net/>

GitHub Repository (Source code): https://github.com/mykushyn/PWS-Applications-of-AI-in-Education/tree/main/AI_pws-main

Images of the Website:

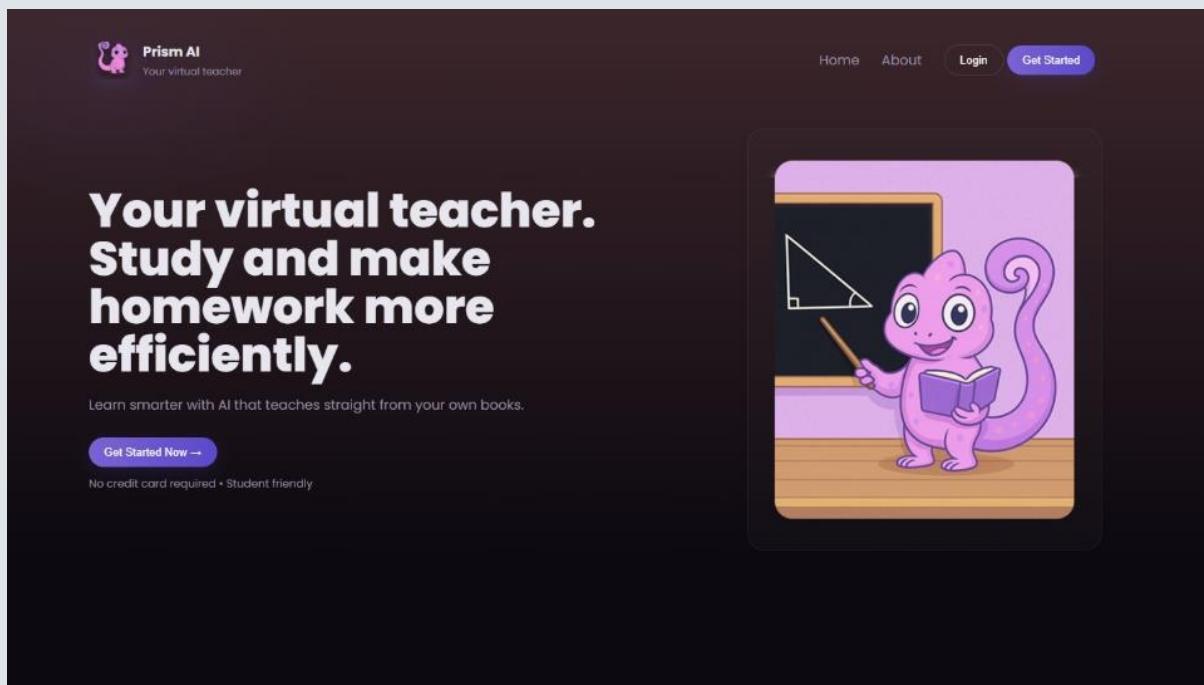
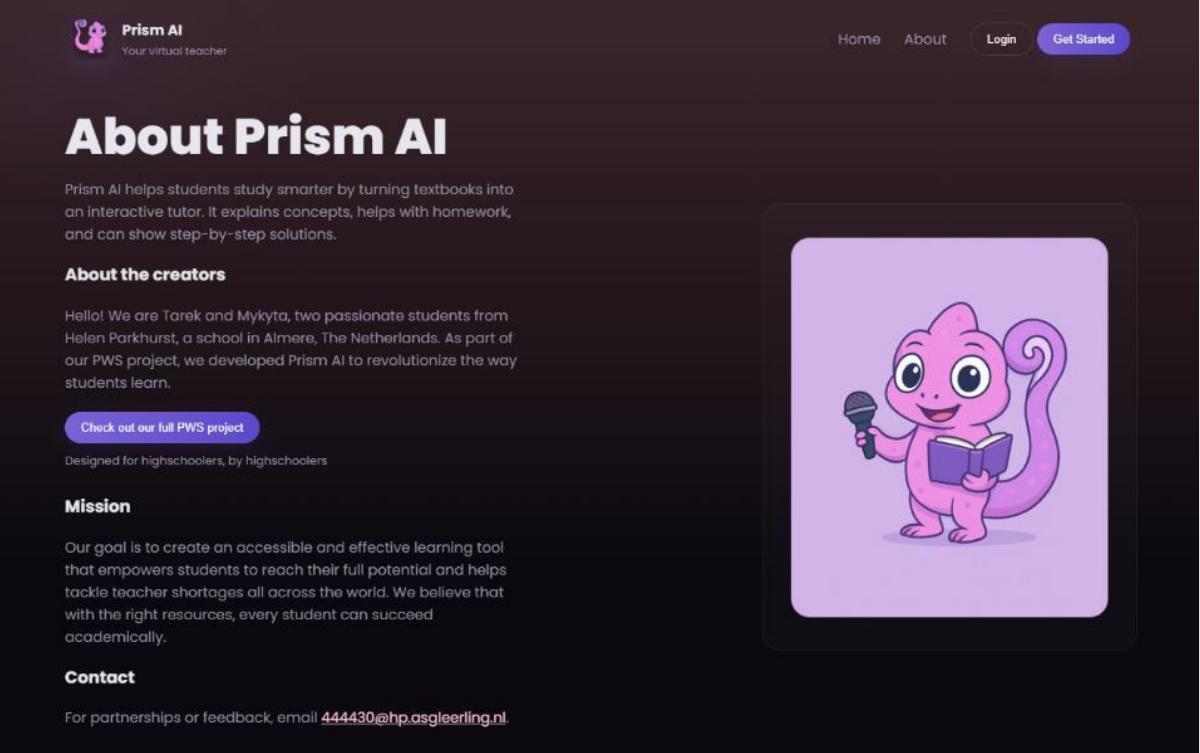
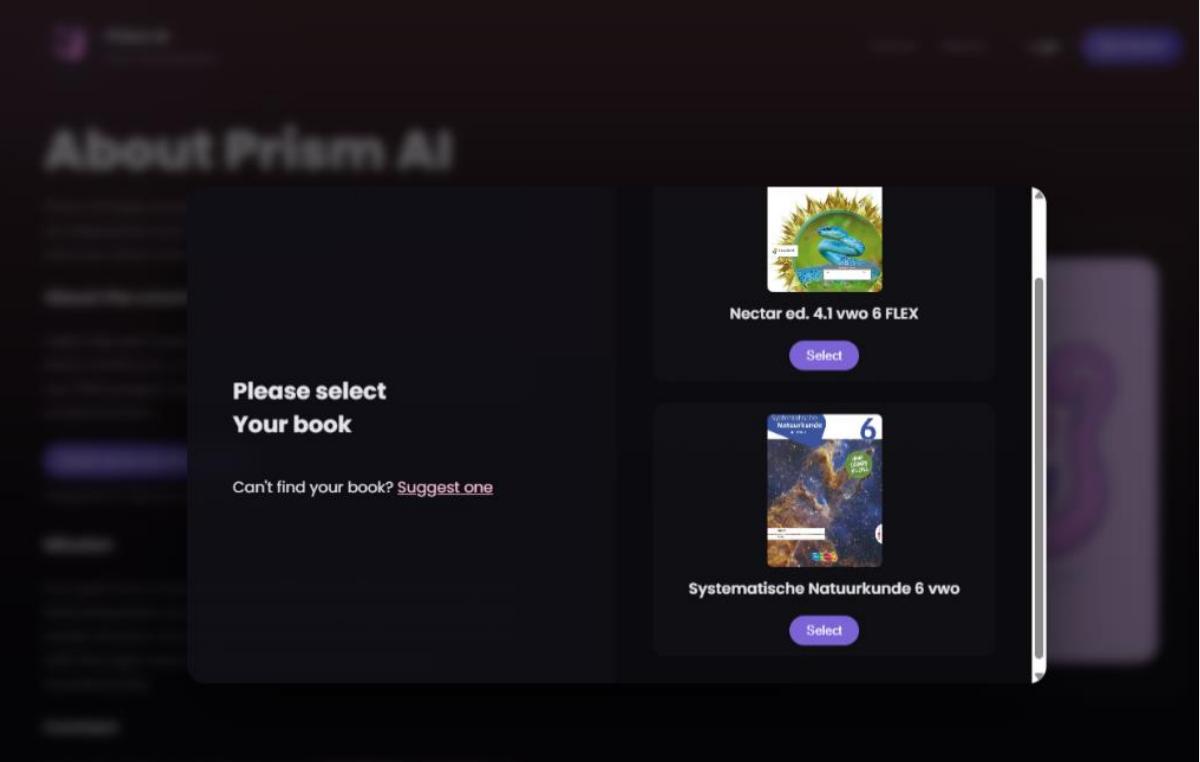


Figure 7- The home page



The screenshot shows the 'About' page of the Prism AI website. At the top left is the logo 'Prism AI' with the tagline 'Your virtual teacher'. Top right buttons include 'Home', 'About', 'Login', and a blue 'Get Started' button. The main title 'About Prism AI' is in large bold letters. Below it, a paragraph explains that Prism AI helps students study smarter by turning textbooks into interactive tutors. A section titled 'About the creators' features a bio for Tarek and Mykyta, two students from Helen Parkhurst school in Almere, The Netherlands, who developed the project. It includes a link to their full PWS project and a statement that the tool is designed for high schoolers by high schoolers. A mission statement emphasizes creating an accessible learning tool to empower students and tackle teacher shortages. A contact section provides an email address for partnerships or feedback. To the right of the text is a pink cartoon squirrel holding a microphone and a book, set against a light purple background.

Figure 8 – The about page



The screenshot shows the book selection page of the Prism AI website. The title 'About Prism AI' is visible at the top. The main content area has a dark background with a central white card. The card contains the text 'Please select Your book' and a link 'Can't find your book? [Suggest one](#)'. Two book covers are shown: 'Nectar ed. 4.1 vwo 6 FLEX' with a green cover featuring a sun and a snake, and 'Systematische Natuurkunde 6 vwo' with a blue cover featuring a globe and the number 6. Each book cover has a 'Select' button below it. The overall design is clean and modern.

Figure 9 – The book selection page

Appendices

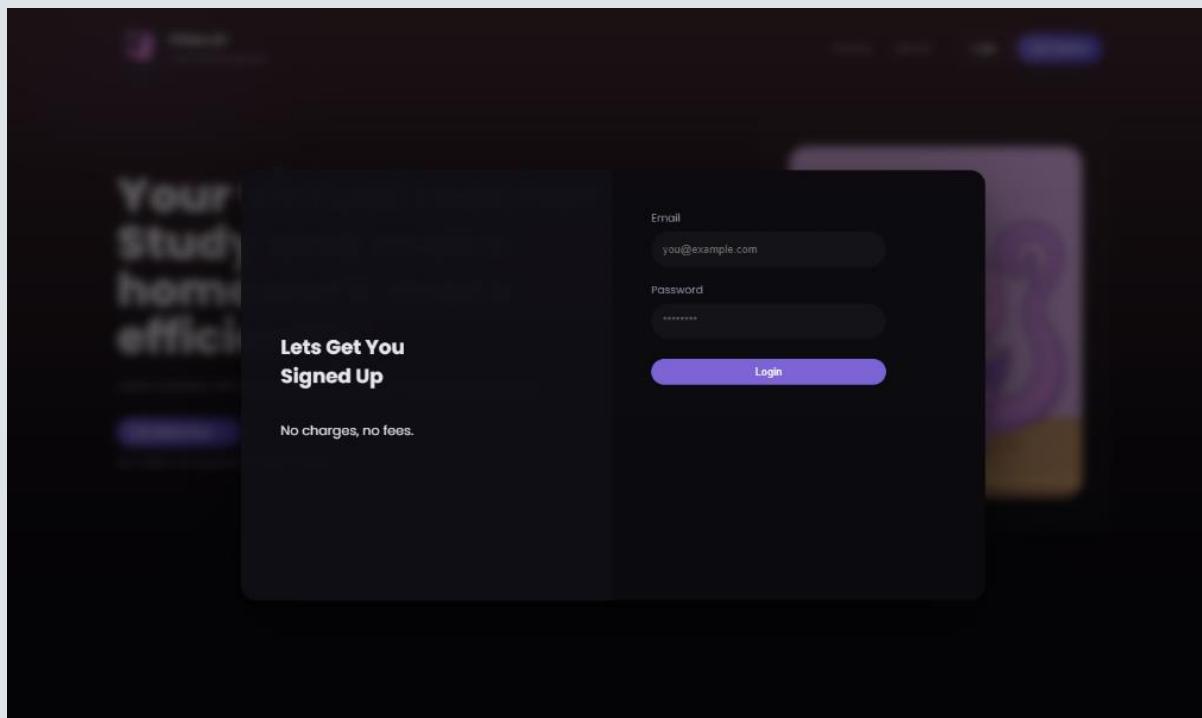


Figure 4 – The login page

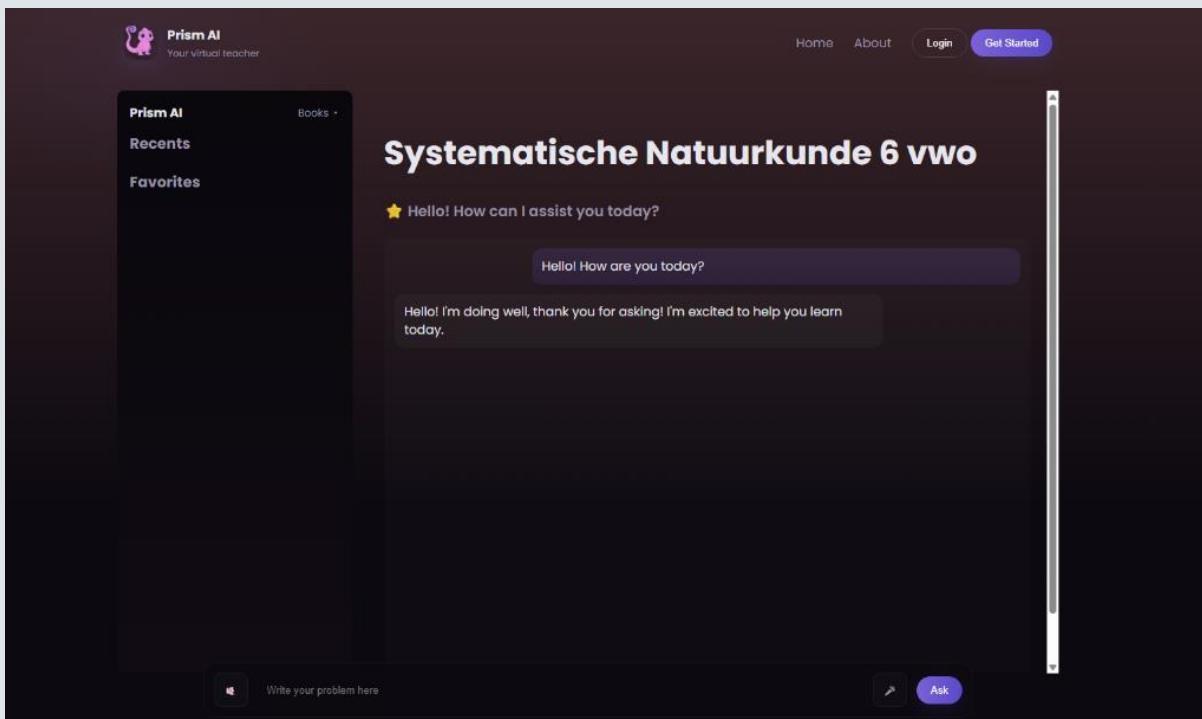


Figure 5 – The AI page

B Interviews

Teachers

Teacher 1 (Language – English)

Summary of Key Points

1. Pessimistic attitude toward AI in education
 - The teacher is generally negative or cautious about using AI in education.
2. Decline in critical and cognitive skills
 - AI can reduce people's independent thinking, creativity, and critical reasoning.
 - The teacher fears students may become dependent on technology instead of solving problems themselves.
3. AI as a tool – only under conditions
 - AI is useful only if applied under specific conditions with clear rules.
 - A good AI coach should not give direct answers but guide students through the thinking process.
 - AI should remain neutral, admit mistakes, and not simulate artificial sympathy.
4. Social consequences
 - The teacher fears AI may reduce social cohesion: less collaboration among students and more individualism.
 - Human interaction is essential in education.
5. Teacher's personal use of AI
 - The teacher occasionally uses AI to summarize lesson material or analyze texts, but not for grading or visual content.

- AI results are often inaccurate or unreliable, requiring extra time to verify.

- He believes grading and assessment require human insight that AI cannot replace.

6. Inclusivity and inequality

- He doubts that AI will globally promote greater equality in education.
- In regions without good infrastructure (e.g., Africa), AI may actually increase disparities, due to unequal access to internet and computers.

7. Philosophical and societal concerns

- AI can encourage a “quick gratification culture,” where students do not learn patience or independent work.
- AI may be useful in the short term but could have harmful effects on learning habits and society in the long term.

8. General attitude

- The teacher describes himself as conservative and anti-AI, but not entirely against technological progress.
- AI should be used critically and responsibly, with attention to long-term consequences.

Teacher 2 (Social Studies – Economics)

Summary of Key Points

1. General attitude toward AI

- The teacher is cautiously positive but emphasizes that AI should be a tool, not a replacement for the teacher.
- He sees potential for AI to make education more efficient but fears the loss of human values and skills if misused.

2. Current usage experience

- The teacher occasionally uses AI, for example to generate ideas or check texts.
- He does not fully trust AI, as it often provides inaccurate or superficial answers.
- Human oversight remains essential.

3. Positive possibilities of AI in education

- AI can provide students with personalized explanations and adapt to their level and pace.
- It can relieve teachers by automating simple or repetitive tasks (e.g., grading or planning).
- The teacher believes AI can help identify where a student is struggling more quickly.

4. Risks and concerns

- Students may become too dependent on AI, reducing critical thinking skills.
- AI could cause “mental laziness,” where students prefer asking AI rather than reasoning themselves.
- There is also a risk that AI provides incorrect or biased information, potentially misleading students.

5. Social and ethical impact

- The teacher fears AI may reduce human interaction between students and teachers.
- Learning is also a social process, where emotions, motivation, and personal guidance are crucial.
- AI lacks empathy, intuition, and moral awareness—qualities are essential in education.

6. Conditions for responsible use

- AI should be used as a supporting assistant, not as a replacement.
- The system must be transparent about how it generates answers.
- AI should encourage thinking, not just provide answers.

7. Inequality and accessibility

- AI only works where there is access to technology and the internet, which some countries or schools lack.
- This could increase educational inequality rather than reduce it.

8. Philosophical perspective

- The teacher draws a parallel with calculators: useful, but dangerous if basic thinking skills are lost.
- Society often embraces technology too quickly without considering long-term effects on learning and humanity.

Teacher 3 (Science – Computer Science)

Summary of Key Points

1. General attitude toward AI

- The teacher sees AI as a useful tool, but not as a replacement for human intelligence or guidance.
- He emphasizes that AI must be used consciously and critically, especially in education.
- He recognizes AI's great potential but remains cautious due to the possibility of errors and hallucinations.

2. Personal experience with AI

- He occasionally uses AI for ideas, explanations, or minor technical questions.

- For educational purposes, he uses it only to a limited extent, as AI is not yet reliable enough for exams, grading, or full lesson preparation.
- AI helps save time and generate ideas.

3. Possibilities of AI in education

- AI can play a supportive role, for example in grading or lesson planning.
- It can assist in personal guidance of students, if applied correctly.
- AI can help reduce teacher workload, especially as it becomes more reliable.

4. Risks and concerns

- AI may affect students' skills, such as writing, reasoning, and critical thinking.
- Overdependence can lead to developmental delays ("mental laziness").
- Loss of human contact and empathy is a significant risk.
- AI may increase inequality, since not everyone has access to the same technology.

5. Human contact and pedagogy

- The teacher asserts that pedagogical tasks cannot be replaced by AI.
- Learning requires emotional and social interaction between teacher and student.
- AI can simulate feelings but lacks genuine empathy and human warmth.

6. Reliability and bias

- He finds that AI can give feedback on texts or code, but grades or assessments are unreliable.
- This may be due to limitations in how AI learns and reasons.

- He acknowledges that AI is improving, especially in areas like programming.

7. Policy and future at school level

- Schools should have a clear AI policy before implementing AI widely.
- Each subject should have some flexibility, but within general guidelines.
- He supports the use of AI under conditions of transparency, safety, and policy.

8. Role of AI in teacher shortages

- AI can partially help alleviate teacher shortages, for example through supportive guidance.
- However, AI should never be the sole “teacher”—human oversight remains essential.
- Suitable in situations of necessity, such as regions with insufficient teachers.

9. Guidelines for AI-coach development

- An AI educational coach should be designed with the understanding that it will never be perfect.
- Development should be stepwise and evaluative (processing feedback and improving).
- AI should complement, not replace, human contact.
- Its goal should be to support learning, not take over the learning process.

Teacher 4 (Science – Mathematics)

Summary of Key Points

General experience with AI

- Limited practical experience: mainly Copilot and ChatGPT, plus a workshop on AI in education.
- Has not used many other AI tools; occasionally created images or logos.

Attitude toward AI in education

- Sees AI as an opportunity but emphasizes the importance of rules and frameworks.
- Efficiency and analysis: AI can help with administration, analyzing learning outcomes, and lesson preparation.
- Currently not suitable for personal student guidance or pedagogical/psychological support.
 - Reason: these require human interaction, empathy, and emotional insight, which AI cannot yet provide.
- Inclusivity: AI can help in some cases (e.g., students without access to teachers), but current impact is limited.

Applications of AI

- Well-suited for:
 - Grading exams (administrative tasks)
 - Efficient administration
 - Supporting lesson usage and preparation
- Less suitable for:
 - Mathematics (AI performs less well here)
 - Pedagogical guidance, emotionally sensitive tasks, and upbringing
- In the future, AI might be able to read emotions and respond empathetically, but current technology is not ready for this.

AI Educational Coach

- Can be useful for explaining lesson material and real-time support.
- Must be able to dose lesson content and provide explanations.
- AI should not take over teaching or handling personal feelings.
- Simulating sympathy and interaction might be possible in the future but requires further development.

Personal attitude toward AI

- Believes he can adapt to changes AI brings (UX- and growth mindset).
- Concerned about scenarios where AI might take control or be insufficiently transparent.
- Wants humans to retain control over AI.

Teacher 5 (Social Studies – History)

Summary of Key Points

General attitude toward AI

- AI offers many opportunities for education, but teachers often lack sufficient knowledge to guide students effectively.
- Education is slow to adopt new technologies; clear guidelines and policies are needed.

AI as a tool vs. assistant

- Used as a tool (e.g., assignments or translations) and partially as an assistant (e.g., giving explanations or structuring assignments).
- AI helps translate texts into student-friendly language and supports creative tasks, but is not yet used for testing or grading complex answers.

Typically human aspects

- Difficult for AI to replace nuance, context, empathy, motivation, and social interaction.
- AI can never be fully human: empathy is simulated and continuously “prompting,” but without real emotions or closure.

AI learning coach

- Ideal: trained on specific books and grade levels, limited to relevant content.
- Can provide feedback or indicative assessments, but not final grading; human oversight remains essential.
- Mainly suitable for allowing students to practice independently and gain insight into material, with clear disclaimers.

Risks and ethics

- Intensive use can lead to dependency and reduced critical thinking or questioning skills.
- Ethical and environmental issues: AI consumes significant energy and data; simulated empathy can be misleading.
- Privacy: students and teachers must be conscious of what they share with AI, as data is stored.

Practical applications

- Learning through play: e.g., using AI to generate images for learning goals and match them to the textbook.
- AI saves time on repetitive tasks such as translating or creating assignment drafts, but does not replace core skills of teachers or students.
- AI can be useful in certain subjects or assessments, but is not reliable enough to independently evaluate complex subject matter (especially subjects like history or mathematics).

Human interaction

- Crucial for learning; AI can be supportive, but a computer can never fully replace the effect of personal feedback, social interaction, or emotional guidance.

Teacher 6 (Social Studies – Geography)

Summary of Key Points

General Experience with AI

- The teacher started using AI this year, mainly for lesson inspiration and rephrasing test questions.
- Finds AI useful but limited (e.g., not great at creating PowerPoints yet).
- Sees AI as a tool, not a “colleague.”
- Uses mainly Copilot (via school account) and sometimes ChatGPT.

Attitude Toward AI in Education

- Overall positive, but concerned that students might rely too much on AI and stop thinking critically.
- Believes AI should be used as a checking or reflection tool, not to do students’ core learning work.
- Encourages students to use AI for self-assessment or reformulation, but not to replace thinking.

Opportunities of AI

- AI could save time for teachers by checking student work automatically.

Concerns

- Observes that some students already struggle to form sentences or explain reasoning because they rely on AI.
- Worries that without proper guidance, students won’t understand what they learn or how to think independently.

- Questions AI's accuracy and bias, since much information may come from unreliable sources.

Workshops and Training

- Attended a workshop on AI in writing education, which emphasized AI in the brainstorming and co-creation phase.
- Prefers students to still write themselves; fears they may lose creativity if AI writes everything.

View on AI-Coach

- Thinks it could assist students at home and save teacher time, especially for checking smaller tasks.
- Suggests a hybrid approach — students still receive explanation from teachers but AI could supplement this.

Philosophy on AI Integration

- AI is “here to stay”; banning it (like phones) won’t work.
- Schools need to adapt and find a balance between AI support and genuine learning.
- Students must learn how to think, not just how to prompt AI.
- AI can help creativity and efficiency, but human insight and reflection must remain central.

Teacher 7 (Social Studies)

Summary of Key Points

General Attitude Toward AI

- Initially curious and fascinated, especially by ChatGPT and early image generators (e.g. DALL·E).
- Actively experimented with AI due to involvement in the art world and common curiosity.
- Eventually, became much more critical and concerned, especially as a teacher and citizen.

Personal Use of AI

- Uses Gemini occasionally because it is integrated into Google search.
- Sometimes uses Copilot and ChatGPT.
- Actively tries to avoid using AI whenever possible.
- Only uses AI when:
 - Information cannot be found via Google
 - He is stuck in lesson preparation
- Believes AI consumes extremely high energy (environmental concern).

AI as a Technological Dilemma

- Believes society is now entering a new critical phase (bubble) again.
- Refers to restrictions such as Australia banning social media under 16.
- Thinks tighter regulation of AI is likely in the future.

Cognitive & Learning Skills Decline

- Refers to MIT's research showing that unused skills degenerate
- Main worry:
 - Teachers already have learning skills
 - Students do not develop them at all when AI replaces thinking
- Warns that this happens during a crucial developmental phase in students' lives.

Loss of Essential Learning Processes

- Students previously had to:
 - Search for sources
 - Evaluate reliability
 - Filter information

- Formulate good research questions
- Now students simply:
 - Paste everything into ChatGPT
 - Ask it to “work it out”
- Result:
 - The AI learns, but the student does not
 - Students memorize AI output without understanding
- School is about learning how to learn, not just facts.
- Example:
 - The Pythagorean theorem is rarely used later
 - But the thinking level developed through it is crucial
- AI risks turning students into passive consumers instead of thinkers.

Misuse of AI by Students

- Many student assignments are now almost entirely AI-generated.
- Students cannot explain or defend their own work afterward.
- Teachers currently lack an effective solution to prevent misuse.
- One response is returning to handwritten, in-class assignments.

Problems With Assessment & Research

- Large research projects can no longer be trusted as original.
- Even field research can now be fabricated with AI.
- Teachers are considering switching to presentations instead of written research.
- The school is still uncertain how to assess skills fairly.

Use of AI in His Own Subject (Social Studies)

- He does not use AI in his teaching.
- Tried it for:
 - Test questions
 - Source-based assignments
- Stopped using it because AI:
 - Hallucinates sources
 - Is not 100% reliable
- Even 90% accuracy is unacceptable because it can spread misinformation.

Problems With AI Accuracy

- Students use AI tutoring tools that contradict teachers' answers.
- AI often produces incorrect explanations.
- AI is described as:
 - A word predictor
 - Without real understanding or context
- Students must still verify everything manually using textbooks.

AI and Visual Content

- Does not use AI for images.
- Prefers real photographs over generated visuals.

AI Coach & Teacher Shortage

- Believes that AI cannot replace teachers.
- Main objection:
 - Low accuracy of current AI systems
- Maybe useful in the future, but not yet reliable enough.

Learning vs. Answer-Giving

- AI, which gives direct answers, causes students to skip essential learning steps.
- Watching YouTube explanations can help, but:
 - Students still need to read, analyze, and answer questions themselves
- Example:
 - Watching videos does not replace doing the actual exam tasks
 - Just like watching driving videos does not replace driving practice

Brainstorming as the Only Valuable AI Function

- Finds AI useful for:
 - Brainstorming
 - Generating questions
- Refers to research by John Hattie:
 - Asking questions and creating test questions has a high learning impact
- A good AI coach should:
 - Challenge students
 - Ask follow-up questions
 - Expose misconceptions
 - Not provide direct answers

Role of the Teacher

- Teachers remain essential for:
 - Pedagogical relationships

- Cognitive development
- Student motivation
- Face-to-face teacher-student interaction has the strongest effect on learning outcomes.

AI and Empathy

- Mentions experiments with AI doctors that were rated as more empathetic than real doctors.

Evaluation of the Website & AI-coach Prototype

- Finds the project interesting and innovative.
- Curious about how well the AI system actually works with real textbook content.

Students

Student 1

Summary of Key Points

General Use of AI

- Mainly uses ChatGPT for homework and general questions.
- Occasionally uses Gemini/Copilot, but rarely.
- Tries not to become too dependent on AI and still works independently.
- Sees AI primarily as a tool, not as a personal threat.
- Does acknowledge that AI could become a global-level threat in the future.

Concerns About AI

- Worries about misuse by governments or countries.
- Sees deepfakes as a serious risk.

- Nevertheless, believes in a mostly peaceful future with AI.

AI in Education

- Sees AI as a possible solution to the teacher shortage.
- Believes AI can reduce teachers' workload, allowing them to focus more on students.
- Thinks AI is especially useful when students are at home and cannot ask teachers questions.
- Believes AI should support teachers, not replace them.
- Emotional and pedagogical support must remain a human responsibility.

Pedagogical and Emotional Role of AI

- AI can help with planning and motivation.
- Does not believe emotional bonding with AI is meaningful.
- Real emotional support after setbacks (e.g., bad grades) should come from a teacher, not AI.

AI Coach – Features

- Finds multiple voice options (male/female) useful.
- Would use the AI coach at school if it works properly.
- Would probably not pay personally, prefers it to be funded by the school.
- Acceptable price estimation: no more than €15–20 per month.

Website Evaluation

- Positive about the clean and professional design.
- The website looks clear and well-structured.
- Some images feel random and not fully aligned with the overall style.

Suggestions for improvement:

Add user reviews

Expand the footer with more information

Book Selection & Navigation

- Current book selection is clear for now, but:

With many books it may become confusing and overcrowded.

Suggests using filters for better navigation.

AI in Combination with Textbooks

- Thinks automatic linking to the next exercises/questions would be very helpful.
- Sees potential copyright issues with publishers.
- The AI should not provide direct homework answers.
- The AI should help students understand, not copy solutions.

What the AI Coach Should NOT do

- Not give direct answers immediately.
- Not solve tasks too quickly.
- Not drift off topic.
- May have an emotional support function, but only in a limited, supportive way.

Overall Conclusion

- Very positive about the concept and execution.
- Would actively use the AI coach if implemented well.
- Believes the project has a high chance of success.
- Has no major negative criticism.

Student 2

Summary of Key Points

General View on AI in Education

- Thinks AI can be very helpful for students if it is used the right way.
- Believes that if students let AI do everything, the quality of their learning goes down.
- Says AI should help you think, not think for you.
- AI is fine as long as it is used as a tool, not as a replacement for your own work.

Good vs. Bad Use of AI

- Good use: AI gives hints, explanations, and support — like a teacher would.
- Bad use: Letting AI write full assignments or answers without understanding them.

Human Parts of Education

- School is not only about learning theory; it also helps students grow socially and emotionally.
- AIs cannot replace the “human side” of teaching, like guidance, support, or understanding feelings.
- Believe students still need real teachers for their development.

AI Coach Idea

- Thinks an AI coach could be useful, especially when students are at home and have questions.
- AI should not give answers right away but should help students think for themselves.
- The coach should act like a teacher — guiding, not solving everything.

What AI Should Be Able to Do

- Help students reason through problems.
- Push students to think instead of giving the full solution.
- Give feedback, but not overly positive or fake.

Concerns and Risks

- Worries that students might rely too much on AI.
- Think students may lose critical thinking if AI does all the steps.
- It says that public AI tools (like ChatGPT) can't be monitored by teachers, so students might cheat easily.
- Points out that if students' hand in AI-written work without reading it, they learn nothing.

Human Interaction

- Human contact is still very important, especially for younger students.
- School cannot become "just a chatbot."
- Social development could be harmed if AI takes over too much.
- Believes AI cannot balance feedback as well as a real person.

AI Feedback (Encouragement)

- Positive feedback is fine, but it shouldn't be fake.
- Says AI might make students feel better than they actually perform.
- A human teacher understands better when to push and when to praise.

Ideal Collaboration Between Teacher and AI

- AI should support teachers, not replace them.
- Teachers do human work, and AI helps with extra support.

- AI can help outside school hours, since teachers cannot help 24/7.
- The student believes AI and teachers should work together, each doing what they do best.

Overall Conclusion

- The student is positive about using AI in school if it is used correctly.
- AI should never take over the teacher's role.
- An AI coach is helpful for extra support, especially at home, but it must not give answers directly.
- Human teachers remain important for real learning, guidance, and emotional support.

C Survey

Link: [Onderzoek naar applicaties van Generative AI in het onderwijs| – Fill out form](#)

Plain survey (in Dutch):

Deze enquête is onderdeel van ons profielwerkstuk (PWS). Het doel is om inzicht te krijgen in hoe docenten en leerlingen denken over het gebruik van kunstmatige intelligentie (AI) in het onderwijs. Deelname is volledig anoniem. De antwoorden worden uitsluitend gebruikt voor dit schoolproject.

Section 1: Algemene vragen

1. Wat is uw rol? (verplicht)

Leerling

Docent

Section 2: Docenten – Voortgezet onderwijs

2. In welke leerjaren bent u actief? (meervoudige keuze)

Theoretical Framework | Consequences of the teacher shortage for the quality of education

Rewriting the Learning Code | 01 Teacher Shortage | 120

Onderbouw

Bovenbouw

3. Op welk onderwijsniveau bent u actief? (meervoudige keuze)

Mavo

Havo

Vwo

4. Tot welke leeftijdsgroep behoort u?

<25 jaar

25–35 jaar

35–45 jaar

45–55 jaar

55–65 jaar

65 jaar of ouder

5. Hoe bekend bent u met AI-technologie in het algemeen (zoals ChatGPT, AI-tools)? (schaal 1–10)

1 = helemaal niet bekend, 10 = zeer bekend

6. Welke kansen ziet u in het gebruik van AI in het onderwijs? (meervoudige keuze)

Persoonlijker begeleiding

Efficiëntere administratie

Betere analyse van leerresultaten

Ondersteuning bij lesvoorbereiding

Toegankelijkheid en inclusiviteit

Overig: _____

7. Welke zorgen heeft u bij de inzet van AI in het onderwijs? (meervoudige keuze)

Privacy van leerlingen

Minder menselijke interactie

Onbetrouwbaarheid van systemen

Afhankelijkheid van technologie

Financiële aspecten

Overig: _____

8. In hoeverre bent u bezorgd dat AI docenten zou kunnen vervangen? (schaal 1 – 10)

9. In welke mate denkt u zich te kunnen aanpassen aan AI-gerelateerde veranderingen? (schaal 1–10)

10. Welke ondersteuning heeft u nodig om AI verantwoord in te zetten? (meervoudige keuze)

Training

Duidelijke regels

Ethische richtlijnen

Technische ondersteuning

Overig: _____

11. Welke vakken vallen onder uw expertise?

Taalvakken

Exacte vakken

Mens- en maatschappijvakken

Kunst en cultuur

Overig: _____

Theoretical Framework | Consequences of the teacher shortage for the quality of education

Rewriting the Learning Code | 01 Teacher Shortage | 122

Section 3: Taalvakken

12. Gebruikt u momenteel AI-tools in uw lessen?

Ja

Nee

13. Welke AI-tools gebruikt u? (open antwoord)

14. Hoe gebruikt u deze AI-tools? (open antwoord)

15. In welke mate gebruikt u AI voor lesvoorbereiding? (schaal 1–10)

16. In welke mate gebruikt u AI voor feedback op schrijfopdrachten?

(schaal 1 –10)

17. Zou u AI willen gebruiken voor voorbeeldteksten, glossaria of

oefenopdrachten?

(schaal 1–10)

18. Wat is uw algemene oordeel over de implementatie van AI in het onderwijs?

(schaal 1–10)

19. Welke voordelen ziet u voor taalonderwijs? (meervoudige keuze)

Snellere feedback

Hulp bij vertalen

Extra oefenmateriaal

Overig: _____

20. Welke risico's ziet u specifiek bij taalvakken? (open antwoord)
21. Hoe groot is uw vertrouwen in AI bij taalkundige beoordeling? (schaal 1 – 10)
22. Zou u willen dat leerlingen AI gebruiken tijdens schrijfopdrachten (met regels)?

Ja

Nee

Alleen onder begeleiding

Section 4: Exacte vakken

23. Gebruikt u momenteel AI-tools in uw lessen?

Ja

Nee

24. Welke AI-tools gebruikt u? (open antwoord)

25. Hoe gebruikt u deze AI-tools? (open antwoord)

26. In welke mate gebruikt u AI voor het maken of controleren van opgaven en

toetsen? (schaal 1–10)

27. Zou u AI willen gebruiken voor automatische opgaven, oplossingsstappen of nakijkwerk? (schaal 1–10)

28. Hoe beoordeelt u de betrouwbaarheid van AI bij wiskundige uitleg? (schaal 1 –

10)

29. Zou u willen dat leerlingen AI gebruiken tijdens wiskunde-oefenopdrachten

(met regels)?

Ja

Nee

Alleen onder begeleiding

Section 5: Mens – en maatschappijvakken

30. Gebruikt u momenteel AI-tools in uw lessen?

Ja

Nee

31. Welke AI-tools gebruikt u? (open antwoord)

Theoretical Framework | Consequences of the teacher shortage for the quality of education

Rewriting the Learning Code | 01 Teacher Shortage | 124

32. Hoe gebruikt u deze AI-tools? (open antwoord)

33. In welke mate gebruikt u AI voor bronnen of samenvattingen?
(schaal 1 – 10)

34. Zou u AI gebruiken voor analyse van argumentatie of nakijkwerk?
(schaal 1 – 10)

35. Hoeveel zorgen heeft u over bias of onjuiste informatie? (schaal 1 – 10)

36. Hoe belangrijk vindt u kritisch omgaan met AI-informatie? (schaal 1 – 10)

37. Zou u AI inzetten voor casussen of simulaties?

Ja

Nee

Misschien

Overig: _____

38. Zou u willen dat leerlingen AI gebruiken bij creatieve opdrachten
(tekst, beeld,
muziek) met regels?

Ja

Nee

Alleen onder begeleiding

Section 6: Kunst en cultuur

39. Gebruikt u momenteel AI-tools in uw lessen?

Ja

Nee

40. Welke AI-tools gebruikt u? (open antwoord)

41. Hoe gebruikt u deze AI-tools? (open antwoord)

42. In welke mate gebruikt u generatieve AI voor creatieve opdrachten?

(schaal 1 –
10)

43. Hoe beoordeelt u de educatieve waarde van AI-gegenereerde voorbeelden?

(schaal 1–10)

44. Zou u AI inzetten ter ondersteuning van creatieve technieken?

(schaal 1 –10)

45. In hoeverre kan AI creativiteit van leerlingen belemmeren? (schaal 1 –10)

46. Zou u leerlingen AI laten gebruiken tijdens creatieve opdrachten (met regels)?

Ja

Nee

Alleen onder begeleiding

Section 7: Overige vakken

47. Welke les geeft u?

Lichamelijke opvoeding

Overig: _____

48. Gebruikt u AI-tools in uw lessen?

Ja

Nee

49. Hoe gebruikt u AI-tools? (open antwoord)

50. Welke AI-tools gebruikt u? (open antwoord)

51. Ziet u toepassingen voor AI binnen uw vak?

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Ja

Nee

52. Welke toepassingen ziet u? (open antwoord)

Section 8: AI-educational coach (docenten)

53. Zou u een AI-educational coach nuttig vinden? (schaal 1–10)

54. Hoe zou een AI-coach u kunnen ondersteunen? (meervoudige keuze)

Nakijken of correctieondersteuning

Extra uitleg voor leerlingen thuis

Extra uitleg voor leerlingen op school

Aangepaste lesstof per leerling

Tijdsbesparing in voorbereiding

Overig: _____

55. Welke docenttaken zouden niet door een AI-coach mogen worden overgenomen? (open antwoord)

56. Wat moet volgens u worden voorkomen bij het gebruik van een AI-coach? (open antwoord)

Section 9: Leerlingen – Voortgezet onderwijs

57. Wat is je niveau?

Mavo

Havo

Vwo

58. In welke klas zit je?

Onderbouw

Bovenbouw

59. Wat is je leerlingnummer?

60. Hoe bekend ben je met AI in het algemeen? (schaal 1–10)

61. Hoe vaak gebruik je AI-technologie? (schaal 1–10)

62. Hoe kan AI jouw leren verbeteren? (meervoudige keuze)

Extra uitleg op niveau

Sneller antwoord op vragen

Feedback op huiswerk

Oefeningen op maat

Overig: _____

63. Welke zorgen heb je over AI in het onderwijs? (meervoudige keuze)

Verkeerde antwoorden

Minder aandacht van docenten

Afhankelijkheid

Privacy

Overig: _____

64. Vind je het nuttig als school AI inzet?

Ja

Nee

Misschien

Section 10: AI-educational coach (leerlingen)

Theoretical Framework | Consequences of the teacher shortage for the quality of education

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65. Hoe prettig zou je leren van een AI-gestuurde coach vinden?

(schaal 1–10)

66. Welke functies vind je nuttig? (meervoudige keuze)

Extra uitleg

Feedback op opdrachten

Persoonlijk leeradvies

Oefenvragen en testen

Pedagogische hulp

Aangepast niveau

Verschillende stemmen of talen

Overig: _____

67. Wat moet volgens jou worden voorkomen bij een AI-coach? (open antwoord)

Section 11: Afronding

68. Bent u bereid mee te doen aan een vervolginterview?

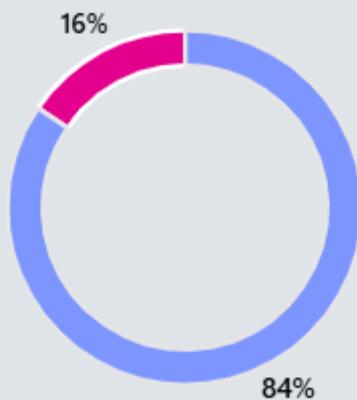
Ja, neem contact op

Nee

D Graphs and Percentages

What is your role?

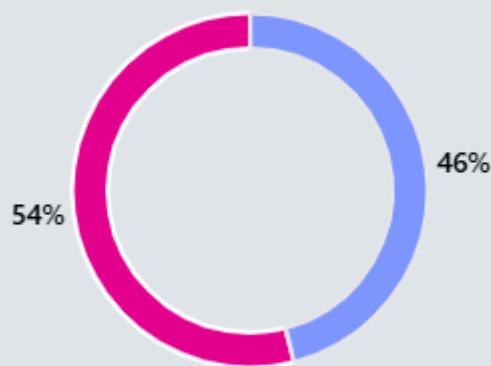
- Student 196
- Teacher 36



Teachers

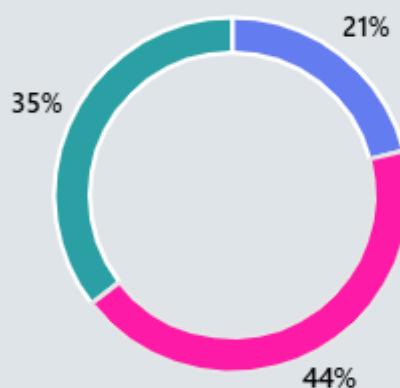
In which grades are you active?

- “Onderbouw” 23
- “Bovenbouw” 27



At what educational level are you active?

- Mavo 13
- Havo 27
- Vwo 22



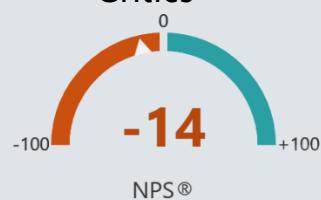
What age group do you belong to?

• < 25 years	1
• 25–35 years	9
• 35–45 years	8
• 45–55 years	13
• 55–65 years	5
• ≥ 65 years	0



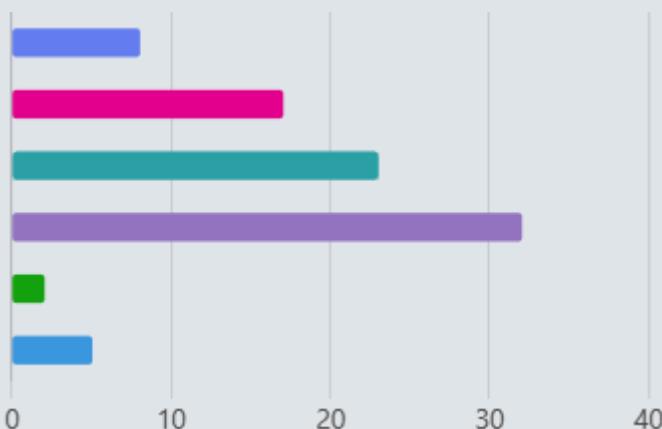
How familiar are you with AI technology in general (such as ChatGPT, AI tools)?

Promoters	7
Passives	17
Critics	12



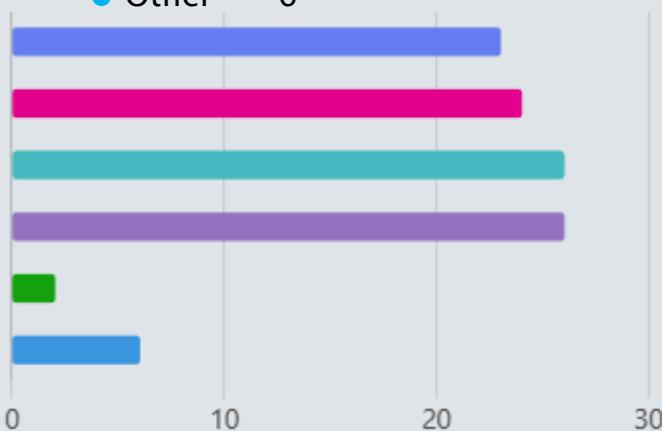
What opportunities do you see in using AI in education?

- Personal guidance of students 8
- More efficient administration 17
- Better analysis of learning outcomes 23
- Support for lesson preparation 32
- Better accessibility and inclusivity 2
- Other 5



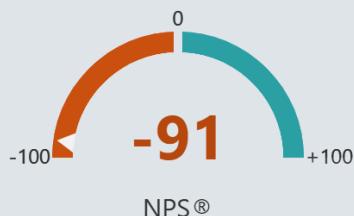
What are your concerns about the use of AI in education?

- Student privacy 23
- Decrease in human interaction 24
- Unreliability of AI systems 26
- Dependence on AI technology 26
- Financial issues 2
- Other 6



To what extent are you concerned that AI could replace teachers?

- | | |
|-----------|----|
| Promoters | 1 |
| Passives | 1 |
| Critics | 34 |

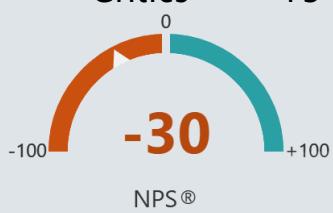


To what extent do you think you can adapt to the changes that AI brings?

Promoters 2

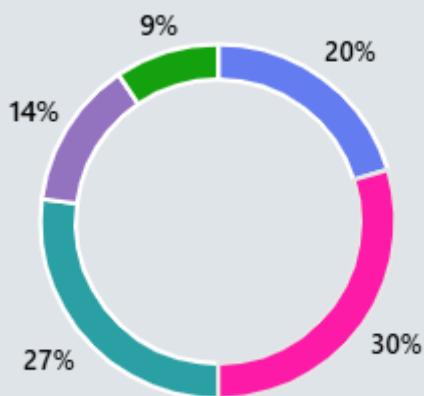
Passives 21

Critics 13



What support do you need to use AI responsibly in your lessons?

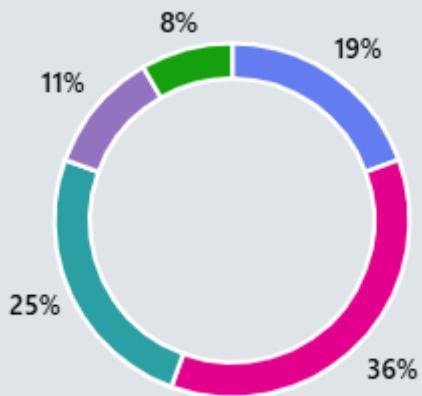
- Training 15
- Clear rules 22
- Ethical guidelines 20
- Technical support 10
- Other 7



Which subjects fall under your expertise?

- Language subjects (e.g., Dutch, English, Latin) 7
- Science subjects (e.g., Mathematics, Physics, Computer Science) 13
- Social Studies (e.g., History, Geography, Economics) 9
- Arts & Culture (e.g., Cultural and Artistic Education, Music, Drama) 4

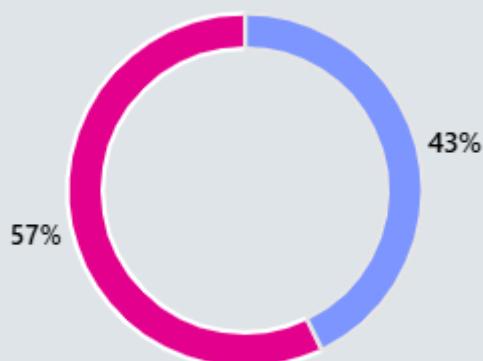
- Other (e.g., Physical Education, Supporting Subjects) 3



Language

Are you currently using AI tools in your lessons?

- Yes 3
- No 4



What AI tools are you currently using in your lessons?

Answer 1 - ChatGPT

Answer 2 - ChatGPT and CoPilot

Answer 3 - ChatGPT and CoPilot

How do you use these AI tools?

Answer 1: "Asking questions and developing learning paths, improving texts."

Answer 2: "For lesson preparation."

Answer 3: "Generate practice tests, essay ideas."

To what extent do you use AI (e.g. ChatGPT) for preparing teaching materials (e.g. texts, assignments, examples)?



To what extent do you use AI to provide feedback on students' writing assignments?



Would you like to use AI tools to generate sample texts, glossaries, or practice assignments?



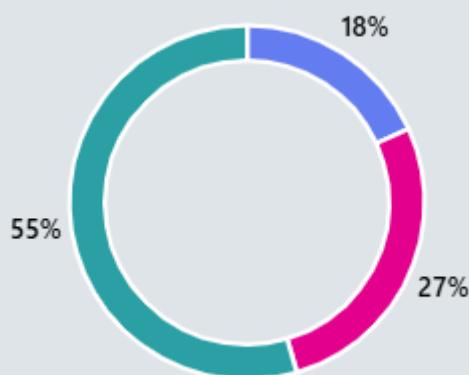
What are your thoughts on the implementation of AI in education?

Promoters 0
Passives 1



What benefits do you see for language education through AI?

- Faster feedback 2
- Translation tool 3
- Additional practice material 6
- Other 0



What specific risks do you see when using AI in language subjects?

Answer 1 – “That students won't have to learn any foreign languages at all.”

Answer 2 – “Mistakes made by AI.”

Answer 3 – “Having to check work generated by AI.”

Answer 4 – “Students no longer learn to think creatively and critically for themselves. It takes away their confidence in their own abilities.”

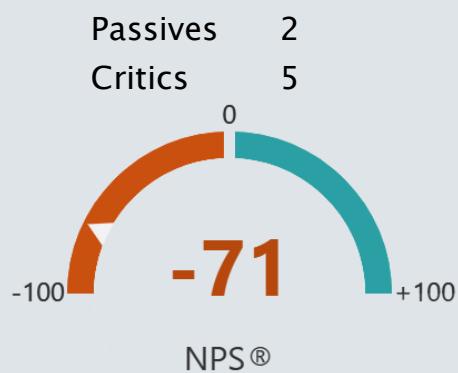
Answer 5 – “None at the moment.”

Answer 6 – “Students no longer learn to write and organize their thoughts themselves.”

Answer 7 – “Mistakes and nonsense presented as if it were official.”

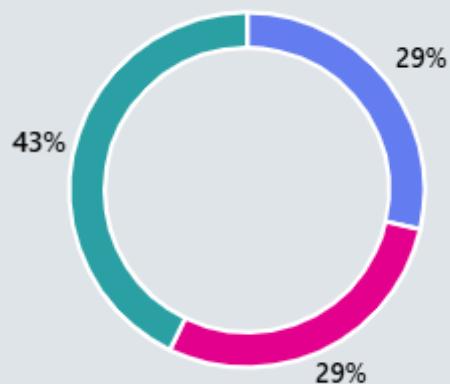
How much confidence do you have in AI when assessing linguistic quality (spelling/grammar/argumentation)?

Promoters 0



Would you like students to use AI during writing assignments (with clear rules)?

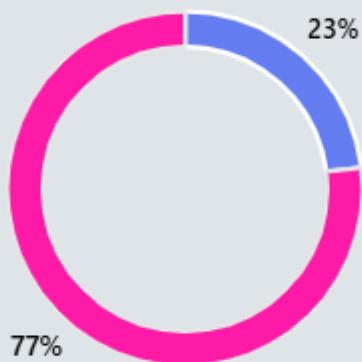
- Yes 2
- No 2
- Only under supervision 3



Science

Are you currently using AI tools in your lessons?

- Yes 3
- No 10



What AI tools are you currently using in your lessons?

Answer 1 – CoPilot

Answer 2 – ChatGPT

Answer 3 – CoPilot

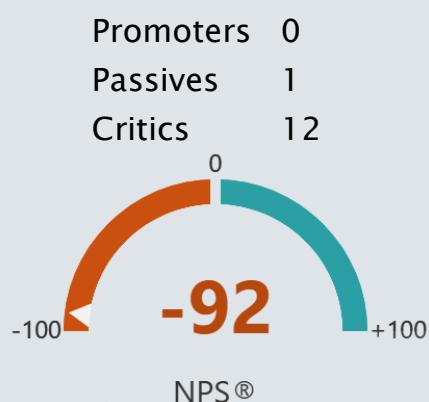
How do you use these AI tools?

Answer 1 – “Feedback on tests and sections, summarizing phone calls, writing emails.”

Answer 2 – “Have questions answered.”

Answer 3 – “Primarily the quick generation of worksheets and additional assignments. Of course, with guidance and then suggestions for improvement from me.”

To what extent do you use AI for creating or checking assignments and tests?



Would you like to use AI to automatically generate or check practice questions/solution steps for students?

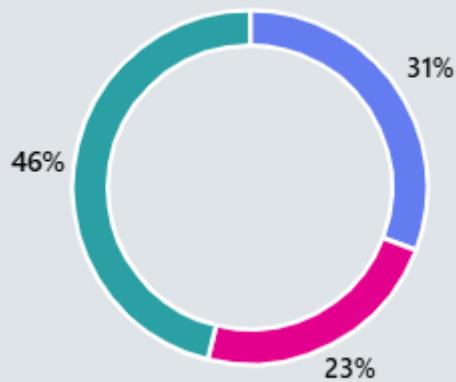


How do you rate the reliability of AI in explaining mathematical reasoning or steps?



Would you like students to use AI during practice assignments (with clear rules)?

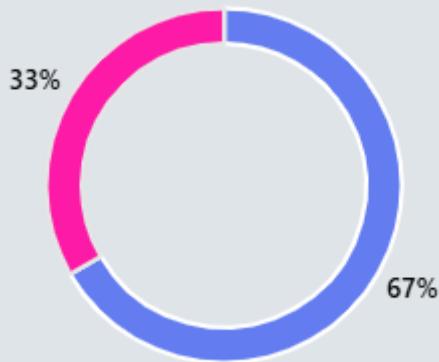
- Yes 4
- No 3
- Only under supervision 6



Social Studies

Are you currently using AI tools in your lessons?

- Yes 6
- No 3



What AI tools are you currently using in your lessons?

Answer 1 - Copilot and ChatGPT

Answer 2 - Claude, nano banana, Gemini

Answer 3 - Copilot, ChatGPT, Gemini

Answer 4 - Information technology

Answer 5 - Copilot

Answer 6 - Copilot

How do you use these AI tools?

Answer 1 - Lesson preparation, test preparation, occasionally structuring texts/emails

Answer 2 - Miscellaneous

Answer 3 - Analysis, developing questions, generating examples

Answer 4 - Lesson preparation

Answer 5 - Devising practice assignments for lesson preparation

Answer 6 - When preparing lessons, generating (practice) test questions, creating starter assignments

To what extent do you use AI to find and summarize sources or teaching materials?

Promoters 0

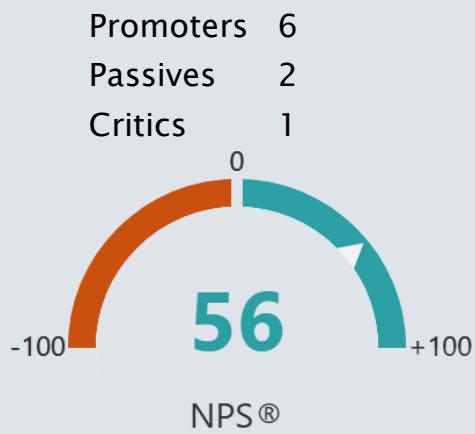
Passives 6



Would you like to use AI to analyze (student) arguments or to check assignments?

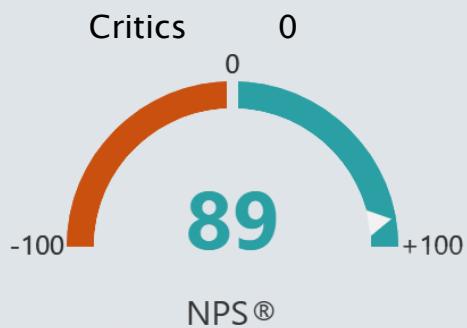


To what extent are you concerned about bias or inaccurate historical/social information from AI-generated sources?



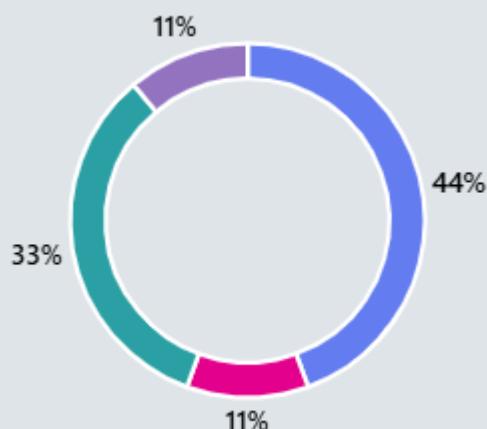
How important do you think it is to teach students to critically engage with information generated by AI?

Promoters	8
Passives	1



Would you use AI to develop cases/simulations (e.g. policy decisions, economic models)?

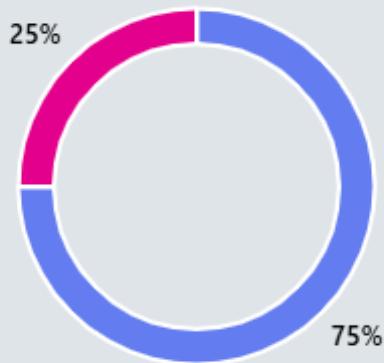
- Yes 4
- No 1
- Maybe 3
- Other 1



Arts & Culture

Are you currently using AI tools in your lessons?

- Yes 3
- No 1



What AI tools are you currently using in your lessons?

Answer 1 – ChatGPT

Answer 2 – ChatGPT

Answer 3 – ChatGPT

How do you use these AI tools?

Answer 1 – “Have students review their work and ask for feedback.”

Answer 2 – “Create assessment rubrics, for example.”

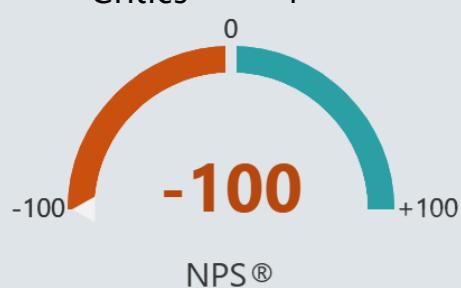
Answer 3 – “Prepare policy.”

Do you use generative AI for creative tasks (text, image, music)?

Promoters 0

Passives 0

Critics 4

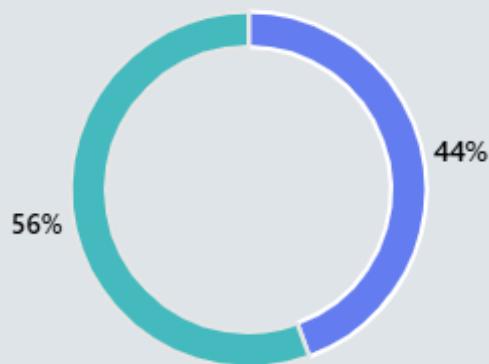


Would you like students to use AI during creative tasks, such as text, image, music (with clear rules)?

● Yes 4

● No 0

● Only under supervision 5



How do you assess the educational value of AI-generated image or music examples in the classroom?



Would you use AI as a tool to demonstrate creative techniques or as a starting point?



To what extent do you think AI can hinder students' creativity?

Promoters	0
Passives	1

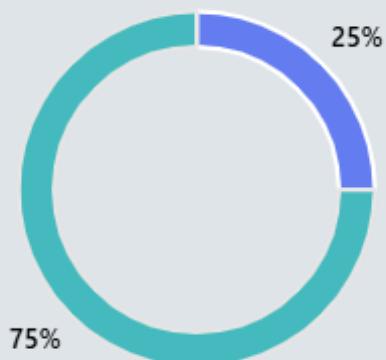


Would you like students to use AI during practice assignments (with clear rules)?

Promoters 1

Passives 0

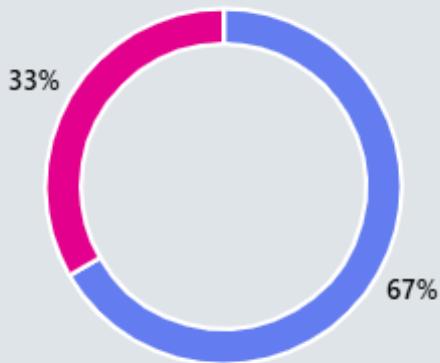
Critics 3



Other

What class do you teach?

- Physical Education 2
- Other 1



Are you currently using AI tools in your lessons?

- Yes 0
- No 3



Do you see applications of AI in your lessons?

- Yes 0
- No 3



What applications of AI do you see in your lessons?

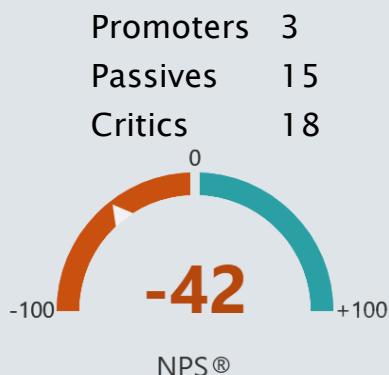
Answer 1 – “Knowledge of the game rules.”

Answer 2 – “No applications.”

Answer 3 – “Not applicable in my role within school.”

Generative AI-educational coach

Would you find an AI-educational coach useful to support students (e.g. with questions, explanations or feedback)?



How could an AI-coach support you in your work?

- Review/correction support 22
- Additional explanations for students (at home) 22
- Additional explanations for students (at school) 12
- Adapted teaching materials for each student 14
- Time-saving preparation 23
- Other 2



Which teacher tasks do you think should not be taken over by an AI educational coach?

Answer 1 – “Conducting practical lessons”

Answer 2 – “Providing feedback”

Answer 3 – “Assessing student work”

Answer 4 – “Conversations with students. Human contact, seeing and being seen.”

Answer 5 – “Personal contact”

Answer 6 – “Level determination”

Answer 7 – “Personal conversations with students”

Answer 8 – “Parenting”

Answer 9 – “Assessment”

Answer 10 – “Mentoring”

Answer 11 – “Instruction with various examples/step-by-step plan”

Answer 12 – N/A

Answer 13 – N/A

Answer 14 – N/A

Answer 15 – “Personal coach, conversations. Feedback on content/knowledge, student mode.”

Answer 16 – “Pedagogical relationship and care for students; making didactic choices; ethical and moral responsibility”

Answer 17 – “Conversations about care, home situation, tutoring, etc.”

Answer 18 – “Personal contact providing feedback”

Answer 19 – “Grading tests”

Answer 20 – “Locations of education. No homeschooling with AI – Personal interaction”

Answer 21 – “Critical thinking”

Answer 22 – “Everything”

Answer 23 – “The entire lesson. I think AI can be used mainly for small parts of the lesson or outside of it.”

Answer 24 – “Human interaction”

Answer 25 – “Social-emotional relationships. Human contact/communication. Second-line support.”

Answer 26 – “The relationship with the student.”

Answer 27 – “Mentoring a student, teaching a learning strategy.”

Answer 28 – “Take tests”

Answer 29 – N/A

Answer 30 – “Interactive assignments, presentations, etc.”

Answer 31 – “Personal interaction, teacher as confidant, open discussion of ethical issues.”

Answer 32 – “Provide targeted explanations and listen to students.”

Answer 33 – “Determine school grades.”

Answer 34 – “Explanation, analysis of errors.”

Answer 35 – “The LLMs so far haven't fully grasped the question or the context in which it's posed. As a result, they provide an answer that is or appears to be correct, but not the actual answer to the question.”

Answer 36 – “The explanation. AI makes stupid mistakes, and we shouldn't be teaching students the wrong technique.”

What do you think would be important to avoid when using an AI coach?

Answer 1 – “The temptation to focus on something else.”

Answer 2 – “Replacing the expertise of trained teachers.”

Answer 3 – “Unclear rules, agreements, and limitations.”

Answer 4 – “Becoming not aware of how to use it correctly. Not seeing the consequences of correct use.”

Answer 5 – “Incorrect information”

Answer 6 – N/A

Answer 7 – “Allowing it to become a cheap solution.”

Answer 8 – “Complete dependence”

Answer 9 – “Students only assessing themselves.”

Answer 10 – “Dehumanization”

Answer 11 – “Not learning”

Answer 12 – “Students no longer invent or produce anything themselves.”

Answer 13 – N/A

Answer 14 – N/A

Answer 15 – “Students always assuming that AI is right.”

Answer 16 – N/A

Answer 17 – “We must prevent students from losing their critical thinking; help prevent fraud. Privacy.”

Answer 18 – “Students don't think critically themselves.”

Answer 19 – N/A

Answer 20 – “Excessive use.”

Answer 21 – N/A

Answer 22 – “Everything”

Answer 23 – “Violation of ethical guidelines, invasion of privacy, teaching/offering incorrect information/incorrect methods to students.”

Answer 24 – “Students stop thinking”

Answer 25 – “Pedagogically and didactically irresponsible matters.”

Answer 26 – “I think it's important to prevent a student from thinking that they can only rely on an AI coach.”

Answer 27 – “No safeguarding privacy, not setting any boundaries.”

Answer 28 – “Privacy leak”

Answer 29 – N/A

Answer 30 – N/A

Answer 31 – “That people become dependent on it. AI will never be perfect, so we must be careful not to rely on it too much.”

Answer 32 – “That students do not become too dependent and remain critical of the output of AI”

Answer 33 – “An excess of influence.”

Answer 34 – “That students no longer think about their mistakes themselves.”

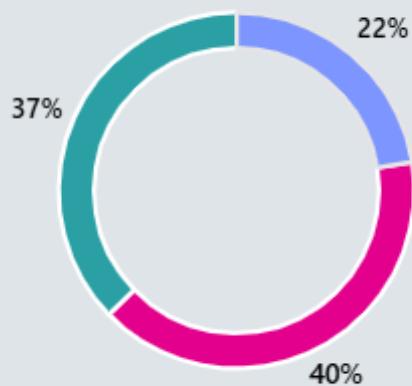
Answer 35 – “People don't fully realize that the lack of AI also means you lose or never acquire the necessary skills in these areas, whether in knowledge and/or skills. Moreover, students, as well as teachers, have unjustified overconfidence in the reliability of information. We're at school, not to complete tests or assignments, but to learn through those assignments. If you don't do the thinking yourself but the AI does, the AI learns nothing, and you don't. Even a teacher who lets the AI grade tests, create lessons, and so on, slowly but surely loses that skill.”

Answer 36 – “That it's not controlled. It can be helpful, but it must be supervised by adults.”

Students

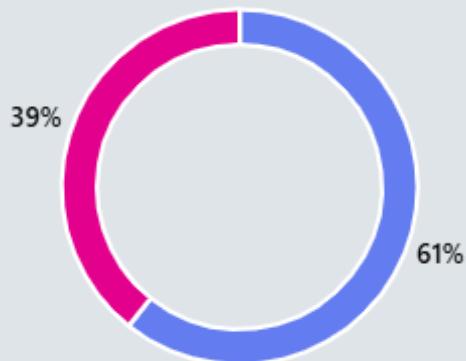
What is your level?

- Mavo 44
- Havo 79
- Vwo 73



What class are you in?

- “Onderbouw” 119
- “Bovenbouw” 77



How familiar are you with AI in general?

- Promoters 55
- Passives 106
- Critics 35



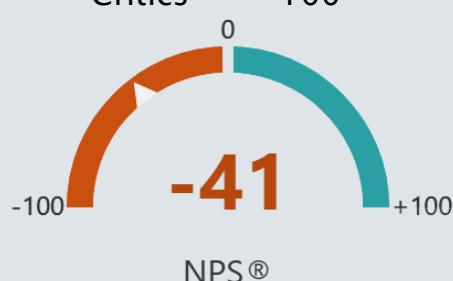
NPS®

How often do you use AI technology (such as ChatGPT, AI tools)?

Promoters 20

Passives 76

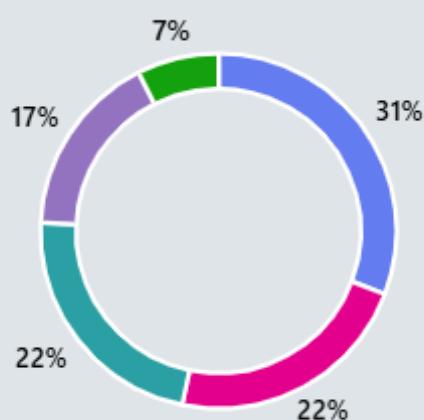
Critics 100



NPS®

How do you think AI can improve your learning?

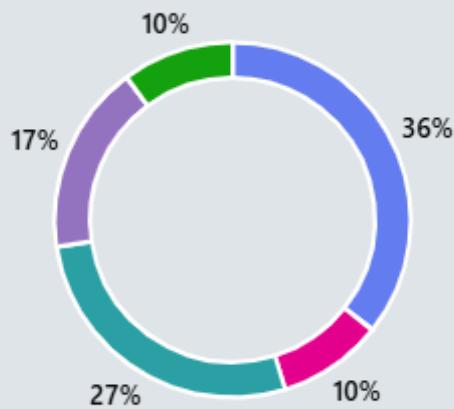
- Additional explanations at my level 141
- Quicker answers to questions 103
- Homework and assignment feedback 103
- Customized exercises 77
- Other 34



What are your concerns about the use of AI in education?

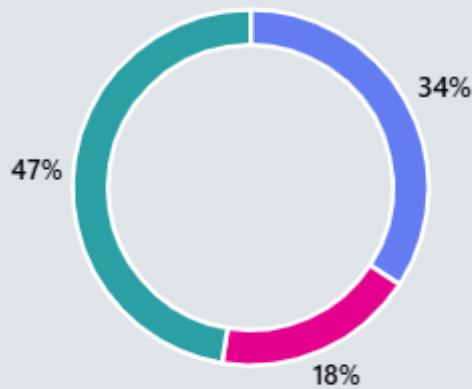
- That AI gives wrong answers 130
- That teachers pay less attention to students 35

- That I am becoming dependent on AI 100
- Privacy of my data 63
- Other 37



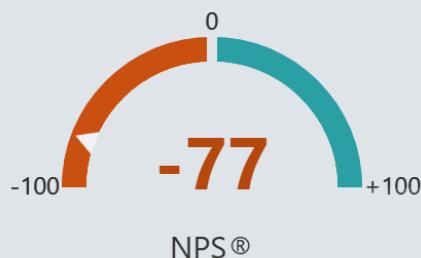
Would you find it useful if your school used AI to help you learn?

- Yes 67
- No 36
- Maybe 93



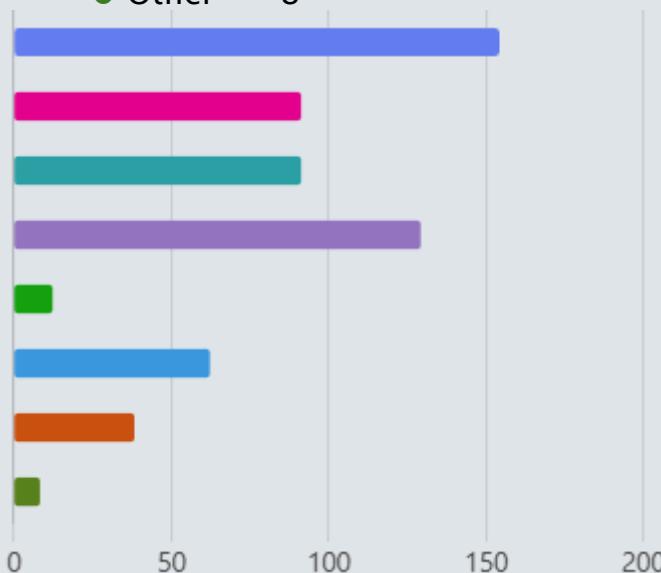
How much would you enjoy learning from an AI-driven teacher?

- Promoters 6
- Passives 33
- Critics 157



What features would you find most useful in an AI coach?

- Additional explanations for difficult topics 154
- Assignment feedback 91
- Personalized learning advice 91
- Practice questions and tests 129
- Pedagogical support 12
- Adaptation to your level of mastery of the material 62
- Various voice/language options 38
- Other 8



What do you think would be important to avoid when using an AI coach?

Answer 1 – "That teachers start making assignments and such with AI without fact-checking."

Answer 2 – "Wrong answers."

Answer 3 – "Wrong answers. That the AI does the work."

Answer 4 – "That it uses terms that are too difficult when explaining a certain topic."

Answer 5 – "That no wrong answers, calculations, or lessons are given."

Answer 6 – "That people don't become too dependent on the AI coach."

Answer 7 – "That good information is given and no wrong information."

Answer 8 – "Just teachers who are well-trained for their jobs."

Answer 9 – "It's important that teachers don't become lazy; it should remain a tool, not replace a human. You should also prevent students from abusing it."

Answer 10 – "That the whole assignment is done by AI."

Answer 11 – "A guideline or some kind of restrictions so you can't misuse it."

Answer 12 – "That AI is more helpful than the teacher."

Answer 13 – "That it replaces teachers and gives wrong answers."

Answer 14 – N/A

Answer 15 – "That teachers aren't completely replaced by AI."

Answer 16 – "That there are enough teachers in education to continue teaching students. I also find social contact with a teacher important and would be a bit unhappy talking to a robot about school. I might as well stay home then. So it's important that teachers get enough representation at school for their hard work, and that we don't have teacher shortages. That way, we don't need an AI coach."

Answer 17 – "Remembering incorrect information."

Answer 18 – "Checking whether everything is explained correctly and that teachers still give attention to their students."

Answer 19 – N/A

Answer 20 – "It's important to prevent becoming too dependent on the AI coach and to protect your privacy."

Answer 21 – "That it takes over the teacher's job. It can be supplementary, but the teacher better understands what material you actually need to know."

Answer 22 – N/A

Answer 23 – "That they give wrong answers."

Answer 24 – "Wrong answers."

Answer 25 – "That you become too dependent on AI and stop thinking for yourself."

Answer 26 – "That they use it during tests or for making summaries."

Answer 27 – "Making sure the answer really matches your level."

Answer 28 – "Fake AI site."

Answer 29 – "That it gives wrong information."

Answer 30 – "Wrong information."

Answer 31 – "Personal data."

Answer 32 – "Misuse — that it answers questions for you."

Answer 33 – N/A

Answer 34 – N/A

Answer 35 – "When using an AI coach, make sure you don't become too dependent, know how your data is used, and that there's always someone to help in difficult situations."

Answer 36 – N/A

Answer 37 – N/A

Answer 38 – "That AI gives hallucinations."

Answer 39 – "That people start asking for answers before doing the assignment."

Answer 40 – "That students just do their work normally without using AI and that we use less AI for work and answers."

Answer 41 – "That we don't become dependent on it."

Answer 42 – "That AI doesn't ask for data."

Answer 43 – "That AI does everything."

Answer 44 – "Wrong advice."

Answer 45 – "Mistakes."

Answer 46 – "That there's no misuse of this feature."

Answer 47 – "Better prepared for the future."

Answer 48 – "Keep data safe and don't share it with everyone."

Answer 49 – "Becoming too dependent."

Answer 50 – "When using an AI coach, it's important to prevent misinformation so that the student learns the right knowledge."

Answer 51 – "That the teacher gives extra explanation and asks students if they understand the material."

Answer 52 – "Don't give too much personal information."

Answer 53 – "That it/he/she does something wrong."

Answer 54 – "That they give wrong information, use inappropriate language, or say unnecessary things."

Answer 55 – "Just no."

Answer 56 – "That you can't do your own work anymore."

Answer 57 – "Wrong answers and bad learning methods."

Answer 58 – "Preventing incorrect answers/explanations."

Answer 59 – "It's important to prevent an AI coach from giving wrong information, sharing personal data, or making people dependent. Also, the

AI should show human understanding and empathy."

Answer 60 – "AI can make a LOT of mistakes; last year in math ChatGPT made many errors."

Answer 61 – "Privacy violation."

Answer 62 – "Don't give direct answers, but hints and tips."

Answer 63 – "Giving wrong answers, which makes me learn it wrong. If we get an AI coach, it should really help properly."

Answer 64 – "Too dependent."

Answer 65 – "That it doesn't make too many mistakes and explains everything according to our textbooks."

Answer 66 – "That it makes mistakes."

Answer 67 – N/A

Answer 68 – N/A "

Answer 69 – "Doing everything for you, because then you learn nothing yourself — still do things from the book."

Answer 70 – "That people will use it to make their reports or POs."

Answer 71 – "Mainly paying attention in class, doing assignments, taking notes, and asking teachers or classmates for help."

Answer 72 – "That it gives wrong answers with full confidence. Also, it shouldn't just give answers, because then it's not a coach anymore — it should first explain and give tips."

Answer 73 – "That they make it too complicated and don't check if someone understands before moving on, and don't explain for too long."

Answer 74 – N/A

Answer 75 – "Making sure it doesn't misunderstand or give wrong answers. And not giving too much personal information."

Answer 76 – "That it doesn't say or teach wrong things."

Answer 77 – "Wrong information."

Answer 78 – N/A

Answer 79 – "It's important to avoid relying too much on AI, sharing personal information, or copying everything without thinking critically."

Answer 80 – "An AI coach can give useful tips, but it's not a real person."

Answer 81 – "To be honest, I would ban AI from school so kids can't use it and have to do homework themselves, depending on teachers to ask questions."

Answer 82 – "With an AI coach it's important to stay critical, protect your privacy, and remember that AI is a tool — not a replacement for human

contact."

Answer 83 – "No wrong answers."

Answer 84 – "That AI doesn't go into weird topics but stays within school subjects."

Answer 85 – "That the information matches our learning method; otherwise, you learn something completely different."

Answer 86 – "That it learns too much about you and sometimes explains answers in a strange way."

Answer 87 – N/A

Answer 88 – "Ask classmates or teachers instead, because they can also know the answer."

Answer 89 – "That it takes over the teacher's entire job — AI is still developing and often gets things wrong. It can also make lessons too detailed and unclear."

Answer 90 – "Wrong answers."

Answer 91 – "That you have to pay for it."

Answer 92 – "That the teacher is not replaced."

Answer 93 – "That kids start asking AI first instead of the teacher. The teacher is qualified and does the job because they like teaching — students should trust them, not AI first."

Answer 94 – "Extra explanation because AI may use a different method than the textbook."

Answer 95 – "Don't always think AI is completely right — AI can make mistakes. Also, don't rely entirely on AI, because teachers can still help."

Answer 96 – "That it feels comfortable for students to talk with the AI and not awkward."

Answer 97 – "That you become too dependent on it, so you stop thinking for yourself."

Answer 98 – "Being too dependent on AI instead of real teachers."

Answer 99 – "Wrong answers."

Answer 100 – "Becoming too dependent on AI or seeing its advice as absolute truth. Having less self-reflection because AI does the thinking. Sharing sensitive information without knowing how it's used. Taking inappropriate or biased advice seriously. Confusing coaching with therapy — AI isn't a replacement for professional help. Not recognizing bias or wrong assumptions in answers."

Answer 101 – "That it doesn't give wrong information so explanations are

always correct."

Answer 102 – "That the school is taken over by AI and you feel unsafe because of data access, fearing it could fall into the wrong hands."

Answer 103 – "That students start talking or trying to test the teacher — that's not the point, but how do you prevent that?"

Answer 104 – "Making mistakes."

Answer 105 – "That students still do things themselves and not everything is done by AI."

Answer 106 – "That we don't force people to use it — some might prefer human help."

Answer 107 – "I'd want to prevent personal information from being used. Also, AI shouldn't be relied on too much — it's fine as a tool, but not as a foundation."

Answer 108 – "Giving too much personal information and the fact that it's not human worries me."

Answer 109 – "A quick summarized answer to your question."

Answer 110 – "That the AI coach gives wrong or inexact answers."

Answer 111 – "Misuse of AI, dependency."

Answer 112 – "That it helps you well or improves your skill level."

Answer 113 – "Private stuff like names or emails."

Answer 114 – N/A

Answer 115 – N/A

Answer 116 – "That it doesn't have bugs or errors."

Answer 117 – "That you can also be independent — for example, a separate hour after school or a Dalton hour for AI-coach lessons, and normal hours for real teachers."

Answer 118 – "Getting used to the AI coach."

Answer 119 – "Privacy violation."

Answer 120 – "That it knows exactly where the student goes wrong and can give advice for improvement."

Answer 121 – "That it gives wrong information."

Answer 122 – "Theoretical instructions, because it often gives different information than the book's theory."

Answer 123 – "That no wrong answers are given and that it stays on the student's level."

Answer 124 – "Not having to use it all the time."

Answer 125 – "Giving wrong answers."

Answer 126 – "That the AI coach gives wrong answers."

Answer 127 – N/A

Answer 128 – "That it accidentally teaches 5 HAVO theory to a 4 HAVO class."

Answer 129 – "No wrong answers."

Answer 130 – "That it suddenly starts acting weird as if it's very smart or something."

Answer 131 – N/A

Answer 132 – "That things are explained incorrectly."

Answer 133 – "The most important thing is that AI helps you learn but still makes you think, practice, and check things yourself, instead of taking over the work."

Answer 134 – "That wrong answers are given."

Answer 135 – "Maybe because it's so easy to become kind of addicted to AI."

Answer 136 – N/A

Answer 137 – "Taking direct answers and letting AI do your work — because in the end, you gain nothing from that."

Answer 138 – "That there's no help from real teachers anymore and that data is collected randomly."

Answer 139 – "1. No internet in class (except in special cases). I actually think it would be best if there were no internet at all in class. So no phones, laptops, or tablets. Just the old-fashioned way: notebooks, books, pens, and pencils. Maybe a PowerPoint explanation from the teacher, but otherwise no screens. 2. The dangers and risks of AI. Every student and teacher should know them — kids will become too dependent on AI and won't be able to do work themselves. It also violates privacy and safety. 3. More headaches, less focus, and overstimulation. Screen use keeps increasing with every generation, and AI makes it worse. It can cause tired eyes, blurry vision, and neck/back pain, leading to headaches and less focus. In short, I'm strongly against AI in general and especially in schools."

Answer 140 – "That it doesn't get overloaded with questions and assignments from students."

Answer 141 – "Incorrect answers."

Answer 142 – "Ask teachers more questions."

Answer 143 – "Overusing AI is bad for the environment and makes people dependent."

Answer 144 – "Sharing too much personal information."

Answer 145 – "Privacy must remain protected, and AI often tells you what you *want* to hear instead of giving real advice."

Answer 146 – "Not telling secrets or anything too personal."

Answer 147 – "That it wouldn't understand us if we can't explain the subject well."

Answer 148 – "That no wrong answers are given."

Answer 149 – "Asking your parents or teacher instead of going straight to ChatGPT."

Answer 150 – "It's important to avoid relying too much on AI, sharing personal information, or stopping critical thinking."

Answer 151 – "Extra explanation and practice tests."

Answer 152 – "Privacy."

Answer 153 – "That the coach literally gives the answers."

Answer 154 – "I think you should prevent AI from doing everything for you, from sharing too much personal data, and from giving wrong information."

Answer 155 – "That they have multiple learning options for people who don't like reading a lot but rather listen"

Answer 156 – "That we are becoming too dependent on AI and that it will eventually become too smart and take over the world."

Answer 157 – "I don't want an AI teacher because AI is already taking over so many things."

Answer 158 – "That the AI coach will explain homework material that you do not need, and that the AI will check the tests and/or POs"

Answer 159 – "Read the books carefully so that you don't need extra help from AI, which sometimes gives wrong answers"

Answer 160 – N/A

Answer 161 – "Study for tests because it can provide incorrect material"

Answer 162 – "That students do not become dependent"

Answer 163 – "The answers they give"

Answer 164 – "That they explain very difficult like ChatGPT"

Answer 165 – "That personal information is shared"

Answer 166 – "Providing wrong information and wrong learning materials."

Answer 167 – N/A

Answer 168 – "That you leave everything to the AI coach, because they can make mistakes. I think it's important to combine such a coach with a real teacher."

Answer 169 – N/A

Answer 170 – "That they give wrong answers"

Answer 171 – "That I don't become dependent on AI"

Answer 172 – "That it does provide correct answers and that it does not make students dependent on it"

Answer 173 – "That it's going to take over the world"

Answer 174 – "That he helps/asks about private things (such as data)"

Answer 175 – "Privacy violation, giving wrong answers"

Answer 176 – "That it doesn't give wrong answers and that it doesn't share your personal data with others, such as hackers or something."

Answer 177 – "Giving advice, I think that AI is not a human and does not know your personal situation so that seems inconvenient to me"

Answer 178 – N/A

Answer 179 – "That the coach is not abused by students"

Answer 180 – "That he is spreading false information."

Answer 181 – "That there are no more teachers to actually teach"

Answer 182 – "That it explains poorly and doesn't show well that it is bad"

Answer 183 – "Become too dependent on it"

Answer 184 – "That it replaces teachers"

Answer 185 – "An AI coach can offer good advice, but they don't understand people the way a real person does. Therefore, it's important to think for yourself and also ask for help from people like teachers, coaches, or friends."

Answer 186 – "That you don't become dependent on it"

Answer 187 – "That not everything becomes ai"

Answer 188 – "That there are fewer than 2 or more teachers in a class. If more than 2 teachers, they can spend more time per student and answer more questions faster."

Answer 189 – "That he doesn't give stupid answers"

Answer 190 – "Become dependent on AI"

Answer 191 – "That people are no longer creative themselves"

Answer 192 – "Use bad prompt"

Answer 193 – N/A

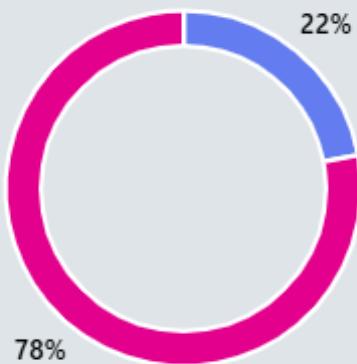
Answer 194 – "That AI steals data"

Answer 195 – "Poor data privacy"

Answer 196 – "That people do not participate in classes because the AI cannot intervene"

Would you be willing to delve deeper into this topic in a follow-up interview?

- Yes, contact me! 51
- No, I do not want to participate. 181



E Process Reflection

Tarek Almallouhi

When I look back at this project, I realize how much I learned in a short amount of time. At the start, Mykyta and I had many ideas, but we both agreed that we wanted to create something that could help people. When we discovered how serious the teacher shortage is, both in the Netherlands and worldwide, it became clear that this was a topic worth working on. Since I have always been interested in Computer Science and AI, I liked the idea of using technology to support education.

During the research phase, I learned how important it is to understand a problem before trying to solve it. We had to read reports, compare information, and think about what teachers and students really need. Interviewing teachers and collecting survey results helped me see the problem from different perspectives. It also made me more aware of the concerns people have about AI, such as privacy, accuracy, and losing personal contact in education.

The design and coding phase was the part that challenged me the most, but also the part I enjoyed most. I spent a lot of time building the front end of our AI coach, making sure the website looked clear, simple, and easy to use. Connecting all the parts to make the coach work took patience, because sometimes things broke or did not respond as expected. Even small details, like placing buttons correctly or making the layout accessible for different users, required more work than I first expected. But solving those problems step by step taught me a lot about planning, testing, and improving my own code.

Working with a partner also taught me the importance of communication. We had to divide tasks, check each other's work, and make decisions together. Sometimes we had different ideas but discussing them always led to better results. This project made me

realize how helpful teamwork can be when you want to build something meaningful.

In the end, I am proud of what we created. Even though it is just a first version, our AI coach already shows how technology can support students and possibly reduce pressure on teachers. I hope to keep improving it in the future, because the teacher shortage is still a serious issue, and every step toward a solution is valuable. This project has strengthened my interest in coding and AI, and it has shown me that technology can make a real difference when it is used with care and responsibility.

Mykyta Kushynov

Well, where to even begin? We had many ideas when we were deciding what to choose for our project. From the start, we wanted to create something applicable that could help solve real-world problems. The turning point in our decision-making process came when we discovered that there is not only a significant teacher shortage in the Netherlands, but worldwide. We then combined our interests in Computer Science and AI and eventually arrived at our topic: since AI has proven to be a highly applicable and helpful tool, why is there still relatively little focus on using AI in education to help address the teacher shortage?

This led to our final research question: *How can an interactive AI education coach contribute to solving the teacher shortage in education?* We had many ideas, which is why we consulted multiple experts and presented them with our concept of a curriculum-aligned AI coach. The responses included both positive and critical feedback; nevertheless, we carefully took all feedback into account.

Once the project started, we realized that we had to divide the PWS into two main phases: a research phase and a design phase. We understood that in order to develop a valid product, we first needed

in-depth knowledge of the problem, the tasks of teachers (to design an AI coach that meets real requirements), the definition and working principles of AI, and, most importantly, the opinions of teachers and students, as they are the eventual users. We considered many technical tools during development. For example, we chose to use the GPT-4o-Mini model instead of GPT-Realtime-Mini due to budget limitations. Despite these constraints, we successfully created a working prototype of our idea and a potential future solution for the teacher shortage. In the near future, we aim to make significant improvements to our AI coach and further develop this idea, as the teacher shortage remains a serious and urgent global challenge.

