BloomGPT: Using ChatGPT as Learning Assistant in Relation to Bloom's Taxonomy of Educational Objectives

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Abstract

BloomGPT is a project combining ChatGPT to Bloom's taxonomy of educational objectives. We have developed a web application which might be used by the students of any subject, at primary, secondary and higher education. The use of the application is based on Bloom's six cognitive learning processes (remembering, understanding, applying, analysing, evaluating and creating) and the taxonomy's four types of knowledge (factual, conceptual, procedural and metacognitive). The application has been already pilot-tested in an undergraduate History course at the University of Agder. According to the students' feedback, using the application helped them prepare for the classes, be more active during interactive lectures and seminars, and improving their conceptual knowledge (by using ChatGPT as a discussion partner in Socratic dialogues we have designed), their procedural knowledge (as they can better understand how a historian or a history student operates), and their metacognitive knowledge (by reflecting on their own work by comparing it to the work of ChatGPT or by rethinking their own use of the application, individually and collectively). The paper discusses positive and challenging dimensions in using the application and presents our plans for improving it both as teaching and learning assistant. Our future plans include the integration of ChatGPT to assessments and the final exam of the relevant courses, as well as making prompt engineering an active element of learning. The paper functions as an invitation to colleagues and groups who would like to cooperate with us in co-creating an open-source platform that will combine a charge-free LLM to Bloom's taxonomy and other learning theories and methods.

Keywords: *ChatGPT, generative AI, Bloom's taxonomy, cognitive learning, metacognitive learning.*

1. Introduction

Since the beginning of 2023 more and more teachers at various levels of lower and higher education have adopted the use of Large Language Models (LLMs), mainly ChatGPT, as an attractive and at the same time challenging addition to their teaching tools. Student-AI interaction became thus a part of the learning process in various disciplines. ChatGPT in particular became a popular tool soon after its launch as a free tool available for public use in November 2022. Its educational use has been discussed ever since. UNESCO, for example, published in 2023 a quick start guide on how to use ChatGPT in higher education, identifying ten roles this chatbot could play interacting with students, namely the roles of possibility engine, Socratic opponent, collaboration coach, guide on the side, personal tutor, co-designer, exploratorium, study buddy, motivator and dynamic assessor [1]. This paper discusses the past, present and future of a project that my team and I have designed and run at the University of Agder in Norway, using ChatGPT to make teaching more attractive and challenging, in order to improve student-active learning. We have done so by developing and implementing a ChatGPT-powered web application that we call BloomGPT.

As the name reveals, BloomGPT is a project combining ChatGPT to Bloom's taxonomy of educational outcomes, one of the most influential theories of learning. In Spring 2023, we had the idea of developing a web application which could be used by the students of any subject, at any level of education. The use of the application is based on Bloom's six cognitive processes of learning (remembering, understanding, applying, analysing, evaluating and creating) and the taxonomy's four types of knowledge (factual, conceptual, procedural and metacognitive) [2, 3, 4].

The application was pilot-tested in an undergraduate history course at the University of Agder. The students used the application, individually and in colloquium groups, as well as in seminars where students critically analysed the content of the course, prepared their own teaching, analysed and evaluated essays generated by ChatGPT, evaluated the performance of ChatGPT as a student and historian, and reflected on their own Chat-GPT-assisted learning experience. [5, 6]

My plan in the following pages is to briefly present the basic aims of the project and its first results (section 2), and then focus on our next steps and the challenges related to them (section 3). The paper orbits around a core of positive and challenging dimensions of using generative AI as teaching and learning assistant, focusing on how we could empower the positive and face the negative ones.

2. Aims and Results

In the first phase of the BloomGPT project (April–December 2023), a team consisting of a professor of AI (Christian Walter Peter Omlin), an associate professor of educational technology (Alexandra Lazareva), two ICT students (Sondre Netteland and Marthe Flaarønning Bøhmer), two history students (Sondre Vindbo and Michael Aase) and myself designed and developed a ChatGPT-powered web application to be used in university teaching. The project was funded by the University of Agder. Our application was hosted on a local server at the university and used the Microsoft Azure OpenAI API service to ensure compliance with GDPR. We instantiated an AI agent in the Azure cloud, using the GPT 3.5-Turbo model. The application then sent HTTP requests to the Azure cloud agent. Figure 1 shows the interface of Bloom GPT, with modules on the left side and Bloom's cognitive processes on top.

The design idea was simple: to combine the use of ChatGPT with Bloom's taxonomy and use the application for introducing the students to the six cognitive processes and the four knowledge types of the taxonomy. Our main aim was to improve the awareness of the students on the need of approaching and using any kind of sources, historical and contemporary (including LLMs), in a critical way. At the same time, we wanted to make the students (more) aware of the cognitive processes of learning and the different types and levels of knowledge. In terms of student learning, our hope was that having an extra tool in their hands, the students would be more active learners, not only in classroom but also while working in colloquium groups and individually.

The development of BloomGPT included a variation of tasks, as for example the design of the website/interface the students would interact with; prompt engineering that would enable ChatGPT to play the roles of teacher, student, examiner, and Socratic discussion partner; the design of tasks combining six modules of the course with all the cognitive processes of the taxonomy; the development of relevant Application Programming Interfaces (APIs) related to specific tasks; the planning of teaching (which included an introduction to BloomGPT and an introduction to Bloom's taxonomy); the design of a self-report mini-project that would give the students the opportunity to reflect over their learning skills and strategies at the beginning, in the middle and at the end of the semester.
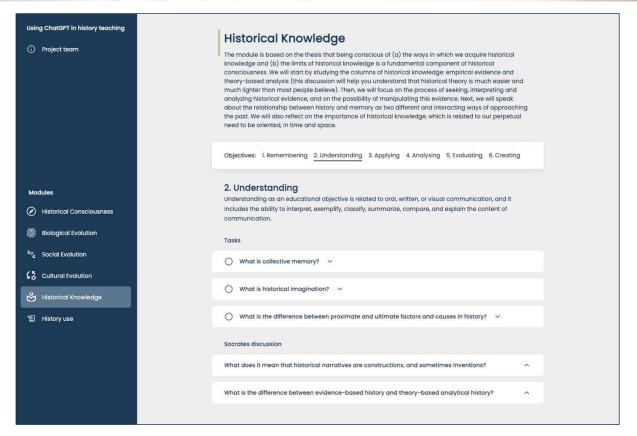
Figure 1. Interface of BloomGPT.

The application was used in the fall semester of 2023 in the teaching of my course "Introduction to historical consciousness" (first year of our Bachelor program in History, 10 ECTS). Forty-eight students participated, one way or another, to activities related to the use of BloomGPT. The teaching of every module had three parts: First, there was an in-class introduction to the module. Second, the students worked in colloquium groups and/or individually on specific BloomGPT-powered tasks designed by the team. Third, the students' work was presented and/or discussed in in-class seminars. In every module, the students used BloomGPT as a starting point to work, explicitly and implicitly, on all six cognitive processes: remembering, understanding, applying, analysing, evaluating and creating. In the seminars, the discussion of the students' work aimed at motivating the students to reflect on the four types of knowledge (factual, conceptual, procedural and metacognitive).

The tasks we designed were of various types. In *Remembering, Understanding, Analysing*, and *Evaluating*, we used "static" tasks in which the students worked on AI-generated texts (static meaning that there was no interaction between student and ChatGPT, the students would simply work on texts pre-generated by ChatGPT). In *Remembering* and *Understanding*, we also included Socratic tasks, in which we prompted ChatGPT to perform by always replying with the generation of a new question, so that the students would get the opportunity to check their knowledge on specific topics. In *Applying*, I wanted my students to learn by teaching, so we prompted ChatGPT to help the students in preparing a Power Point presentation for their teaching, as well as a quiz and a class activity related to their teaching. In *Analysing*, the students analysed ChatGPT-generated texts and in addition they had the possibility of uploading their own texts, in order to get feedback by ChatGPT, which we had prompted to comment in terms of content, language, and structure. In *Evaluating*, the aim was to familiarize the students with the grading criteria of the course; this would be done by letting the students grade a ChatGPT-generated text and compose a legitimization of the grade, which would be discussed in the classroom. *Creating* was related to the final examination of the course, which was individualized, meaning that every student had the right to choose one of four alternative examination forms, two written and two oral. In *Creating*, the students used ChatGPT to generate project ideas for essays or lecture topics that they could include in their exam portfolio.

It is important to underline that it had been made clear to the students that all ChatGPT texts, proposals and replies should be approached critically and, ideally, should be discussed in classroom. Our aim was to use ChatGPT not to find answers but to create factual, conceptual, procedural and metacognitive questions and reflect on them. In relation to factual and conceptual knowledge, ChatGPT was to be used as a Socratic challenger and as a starting point for critical analysis of texts and sources. In addition, using ChatGPT and discussing this use would be an arena for procedural and metacognitive reflection, related to the function of History as a discipline and to the learning skills, methods and strategies of the students, as individuals and members of learning groups.

In addition to the work done in classroom and in colloquium groups, we wanted to give the students the chance to reflect over their learning skills and strategies, as well as their strong and weak sides as learners, in relation to the taxonomy's six cognitive processes and four knowledge types. We did so by asking them to fill in a simple self-report form at the beginning, in the middle and at the end of the semester. The self-reports show that in the nine weeks from the first to the last report, the number of students who perceived remembering, understanding, applying, and analysing as their strong sides was approximately doubled, while the number of students who perceived themselves as weak in creating increased from two students in the first report to eight in the last, in addition to nine students thar reported creating as a neutral (neither strong nor weak) side. In relation to knowledge types, most students presented conceptual and metacognitive knowledge as their strongest sides, while procedural was perceived by most as their weakest. (For more results, see [5].)

According to the students' feedback (in class, in group interviews and in the anonymous evaluation of the course), using the application helped them to get more comfortable in using AI tools; prepare for the classes; be more active during interactive lectures and seminars; improve their conceptual knowledge, by using ChatGPT as a discussion partner in Socratic dialogues; develop their critical thinking; strengthen their procedural knowledge, as they improved their understanding of how a historian or a history student operates; improve their metacognitive knowledge, by reflecting on their own work by comparing it to the work of ChatGPT or by rethinking their own use of the application, individually and collectively; build better collaboration with classmates in groups; understand the importance of prompting while using generative AI tools [5, 6].

Reflecting on my own experience from using BloomGPT as a teaching assistant, I could say that my first and immediate benefit was that I improved my knowledge of LLMs and generative AI, not only as teaching/learning assistants but also in general. In addition, the project gave me the opportunity to cooperate with colleagues working on AI and educational technology, which was in itself a stimulating experience. When it comes to my teaching, implementing a new tool inspired me to rethink my teaching methods in terms of employing the taxonomy in a dialogue between history and generative AI, which resulted in a more creative interaction and cooperation with the students. Regarding the realization of the project, at hindsight I must admit that the time we disposed to each module (four hours) was not enough to work on all tasks.

My evaluation of the students' performance in relation to the use of ChatGPT include very positive results and thought-provoking experiences. In some instances, students surprised us by performing differently than what we had expected. In that, there were positive cases (as for example when both student groups who undertook the task of teaching a module did much more than what ChatGPT had instructed them to do), but also negative surprises (as for example the fact that only nine students volunteered for learning through teaching). Another positive surprise was the way the interviewed students perceived and evaluated the interview as an additional layer of learning, which gave them an extra opportunity to reflect on their own work. In addition, the interviewed students stated that what they experienced as the most meaningful part of using BloomGPT was when ChatGPT-generated texts operated as a starting point for working together with classmates [5].

3. Upgrading Bloom-GPT

The use of LLMs in teaching and learning is not challenge-free. Individual scholars, institutions and organizations have warned of challenges related to academic integrity (plagiarism and cheating), the lack of ethical regulation, privacy concerns (collection of personal data), the LLMs' cognitive biases, including discrimination related to gender and diversity, intensification of the digital divide based on

accessibility to ChatGPT, transparency, and commercialization. There have also been concerns about the possibility that the extensive use of LLMs by students might result in poor critical thinking skills, while at the same time making it difficult for the teachers to evaluate the performance of students. Despite the challenges, using LLMs in teaching has indeed considerable benefits related to activities as for example classroom teaching innovation, student-active learning through experimentation and experience, AI-powered assessments, facilitation of teamwork, personalised tutoring, support of non-native speakers of the tuition language, or support of students with writing challenges [1, 8, 9, 10, 11, 12, 15].

The project team, strengthened with professor of AI Turgay Celik, associate professor of Literature Line Reichelt Føreland and senior engineer Mauricio Cifuentes (all from the University of Agder), has taken into consideration benefits, concerns and challenges in our work so far, which are compass elements in our effort to improve BloomGPT. Our next steps are the development of an improved version of the web application, to be used in Fall 2024, and then the development of an upgraded version that will include new features and possibilities for both teachers and students. The improved version of BloomGPT will be used in the fall semester of 2024 in at least five courses at the University of Agder (my course on historical consciousness, my postgraduate course on historical theory and method, a course on Artificial Intelligence and the internet of things, a course on Norwegian language for Lower Primary School, and a course on Norwegian language for Lower Secondary School).

Our plans for improvement include a technical part related to the application's interface and functionality, and an educational part related to its content and our educational objectives. Technically, we are upgrading the web application's interface, to make it (even) more user friendly. In addition, we are including the possibility of the students chatting with ChatGPT in any topic, a functionality which includes the option of having Socratic dialogues with the chatbot on any subject (and not only on subjects prepared on beforehand by the teachers). We are also working towards making the application open source, so that any interested teacher, at any level of education, would be able to use it.

In regards with the educational upgrade, we are focusing on improving the content of the existing functions, based on the feedback we got from the students in Fall 2023, as well as from colleagues and students who participated in ad hoc arranged workshops in Spring 2024. In addition, we are working towards relating the use of BloomGPT to assessments and the final exam of the relevant courses. The main idea is to work on how the use of ChatGPT might be a part of "assessment for learning" (assessment seeking the improvement of learning and teaching) and "assessment as learning" (self-assessment and self-directed learning) [13]. In the 2023 version of BloomGPT, the students had the chance of grading a ChatGPT-generated text using the grading criteria of the course. What we will work on now is the possibility of ChatGPT commenting on a student essay on the basis of the course's grading criteria.

An additional function will be related to ChatGPT assisting teachers in the creation of BloomGPT tasks for the students. Our basic idea is that we will implement an AI (ChatGPT-based) assistant to our application, which will allow the teacher to upload the teaching material for a module (curriculum texts, learning objectives, PPTs, maps, figures etc.) and get support from the AI assistant in creating relevant tasks, which the students will engage with in class or at home.

We are also working towards making prompt engineering an active element of learning. This is based on the principle that the proper use of generative AI, including of course its proper use in teaching and learning, is based on optimising the prompts we use in our interaction with LLMs. The powerful march of generative AI in social and professional life has made prompt engineering (i.e., the design and refinement of prompts to optimize the AI-generated response) an emergent 21st-century skill for anyone, including teachers and students. High quality prompt engineering can maximize the performance of LLMs in any context. So, the optimal use of LLMs as teaching and learning assistants should include prompt engineering as a tool of optimising the learning results and boosting the students' efficiency as AI-assisted learners. Given that generative AI will most likely be a central part of our lives in the future, letting the students improve their skills in prompt engineering means in fact improving their life skills. At the same time prompt engineering could be a valuable learning method per se. By designing and refining prompts related to factual and conceptual knowledge, students can improve themselves both cognitively and metacognitively. The use of generative AI in teaching and

learning offers this innovative opportunity to enhance student-active learning in a way that is challenging and experimentation-based.

Our work is to be based on what William Cain evaluates as "foundational pillars of prompt engineering", namely content knowledge, critical thinking, and iterative design [14]. Effective prompt engineering is based on a clear understanding of the subject and the relevant objectives (in our case, educational objectives related to factual, conceptual, procedural and metacognitive knowledge) and a good overview of parameters for success. The first can be achieved in the classroom, in colloquium groups and individually, by getting familiar with the objectives of the material of the course. Knowledge of parameters for success can be reached on the basis of basic knowledge on how LLMs function and through exercise related to designing and refining prompts related to the relevant course material and objectives. In addition comes critical thinking which "involves evaluating, verifying, and questioning the AI's outputs", which might be wrong, biased, or unsuitable [14]. Being able to refine our prompts after a critical evaluation of the AI-generated content is crucial for making the interaction with any LLM creative, especially in educational contexts. Finally, prompt engineering should be approached as an iterative process, based on "planning, design, testing, and subsequent refinement". [14] This process improves the critical thinking of students, offering at the same time an excellent opportunity to better study the course material and reflect on it and on their own learning methods and strategies.

Another topic we would like to examine is how we could use the application in relation to examination and assessments. This could be done in two ways: by AI-assisted assessment design and by including a student-ChatGPT interaction in the examination of the students. So far, building up assessment with the use of AI seems to be problematic, especially when ChatGPT's performance in creating assessment scripts is related to Bloom's taxonomy [7]. However, studies are conducted on how to optimize assessment design by employing Bloom's taxonomy, so that the assessments will not be susceptible to AI-generated answers [8]. As the relevant studies will get deeper into the challenges and as the technology of generative AI will improve, we can hope than soon we will be able to use generative AI both in preparing the exams, but also in legitimizing the grading, and sometime in the future rely on AI-assisted grading.

What we are planning is to integrate BloomGPT into examination and assessments with a "human-in-the-loop" approach. LLMs can generate diverse questions, automate grading for objective tasks, provide instant feedback and explanations, adaptively adjust difficulty levels, aid in revision, and detect cheating. As this could create problems, due to AI hallucinations and other issues, human oversight will ensure the quality, accuracy, and fairness of assessments, especially in relation to subjective grading, monitoring adaptive learning processes, and verifying feedback provided by the LLM.

In addition, we are thinking of ways for including a student-AI interaction in the assessment methods of courses implementing BloomGPT. This is an innovative and challenging way of examination, which could be realized in various ways, as for example:

1. By asking the students to evaluate a ChatGPT-generated text, using the grading criteria of the course, and to compose a legitimization of the grade, in which they refer to the grading criteria and the syllabus of the course (this is already pilot-tested as an exercise in my course in 2023 with very good results).

2. By evaluating a Socratic dialogue between students and ChatGPT, where the chatbot is prompted to play the role of Socrates. The role of the examiner here is to evaluate the ways in which students use relevant factual, conceptual and procedural knowledge in the dialogue with the Socratic ChatGPT.

3. By asking the students, individually or in groups, to run a Socratic dialogue with ChatGPT, in which the role of Socrates will be played by the students. The idea is to check the students' knowledge and reflections through the questions that will facilitate the dialogue. Points of assessment could be the following: Do the questions cover the most important elements of the module? Are they expressed at the study level of the course? Are they expressed in academic language? What they initiate productive and learning-provoking answers, had they been posed to actual students?

4. By asking the students to co-author an essay with ChatGPT, making clear in the final product what is AI-generated and what is their own contribution. Such an assessment should include a student metacognitive reflection on their interaction with the ChatGPT, what they learned from it and how, and positive and negative dimensions of such an interaction.

5. By asking the students to work on prompting ChatGPT to perform various tasks related to a module of the course. The final product of such an assessment would not be just the prompts that are evaluated by the students as the optimal ones, but a full log of the whole process of prompting, accompanied by the students' curriculum-based argumentation on positive and negative dimensions of the prompts, as well as their metacognitive reflections on the process.

4. Closing with an Invitation

BloomGPT aims at AI-assisted student-active cognitive and metacognitive learning. Its use is related to domain-specific factual and conceptual knowledge, domain-general procedural knowledge on how the relevant discipline functions and how a student of the discipline is expected to operate, and metacognitive knowledge of the students as learners. In addition to facilitating deeper learning, it aims at improving personalised learning dynamics in an innovative classroom environment, in which students and teachers can co-create knowledge and reflect on it. Furthermore, BloomGPT aims at improving the students' 21st-century skills by making them comfortable and reflected on the use of AI-powered tools in general and generative Ai in particular.

My experience from using BloomGPT in my cooperation with students shows clearly that the application can indeed be used in relation with all six cognitive processes and all four knowledge types categorized in Bloom's taxonomy. In addition, the design and interface of the application makes it available for use in relation to any other learning theory, strategy and method.

I would like to close the paper with an invitation. My colleagues and I would be thrilled to share our insights and plans and cooperate with colleagues and groups who are interested in the dialogue between learning practices and generative AI, and share the passion of improving teaching and learning with the use of an open-source platform that will combine a charge-free LLM to Bloom's taxonomy and other learning theories and methods. We strongly believe that such efforts can only reach optimal results on the basis of interdisciplinary and cross-cultural approaches, and we are looking forward to improving our work in a co-creation endeavour.

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