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Experiences from implementing teach-back In the teaching of Artificial Intelligence

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Abstract
Teach back, initially used in health care, has recently been also applied in higher education, for self-assessment, and to enhance student engagement. These applications, however, have been limited to the field of humanities. In our work, we extend the concept of teach-back to one of our STEM courses, namely "Introduction to Artificial Intelligence". Here, we couple teach-back with the use of study groups. Our goal with this exercise was many-fold. For one, we want to increase student engagement and student activation in the course. Moreover, we want to increase student understanding. Lastly, we want to attain the above with an efficient use of teacher hours. In this paper, we describe how we implemented the teach-back method. Our results show that after introducing teach-back, we have a slightly decreased rate of fails at the oral exam. We also found that students who engaged in the teach-back activity found it mostly beneficial and engaging. Unfortunately, however, it was only a small portion of students who participated in teach-back. Thus, beyond improving the implementation of teach-back, our main target for future work will be to engage more students in it.

Keywords: *student engagement, motivation, teach-back, Artificial Intelligence*

1. Introduction
Artificial Intelligence is a transformative technology that is becoming an integral part of digital literacy, making it a crucial part of modern curricula. Our goal thus is to teach it in an engaging and motivating way. One tool we utilized for this is the method of teach-back. This paper is outlined as follows. The remaining part of this section provides the background for our work. Section 2 describes our methodology, how we implemented teach-back in our classroom. This will be followed by the evaluation of this implementation in Section 3. Lastly, in Section 4 we share our concluding remarks, and outline our approach to future work.

1.1 Related work
The use of teach-back in healthcare has been well researched, from the study reported by Bertak [1] to more recent efforts [2]. The main benefit of this method being that healthcare workers can probe patient understanding of explanations [3]. This provides the opportunity to clear misunderstandings, leads to a significantly improved retention of information [1], and increases patients' health literacy [4]. The idea of adapting teach-back to education arises naturally, as increased literacy of a subject, and better retention are important goals in this area too. The literature on this subject, however, is sparse, mostly limited to the humanities (particularly, the subject of second language acquisition). Early studies, however, suggest that teach-back can be beneficial for student self-assessment [5] and for enhancing engagement [6]. This latter aspect of enhanced student engagement was the primary reason we chose to implement teach-back in our Introduction to AI course.
Unlike the use of teach-back for education, student engagement is an extensively researched subject. A student's investment in learning has been widely defined as cognitive engagement [7]. The first theory is KOLB which suggests the optimal learning process begins from the concrete experience as the learner undertakes an immediate action and then observes a response to the effect of the experience [8]. Kolb's theory relates to the internal cognitive processes of learners by always providing clearer examples of how to solve the problem and the need to think out of the box, do not fear being wrong, break up the problem into smaller parts, get ideas from others, and keep on looking for a better answer. All the previous examples will lead to working with a problem in a scientific and research-based way without killing innovative thinking by fearing being wrong. The reflection point stated in KOLB will lead to a better and more concrete experience. Using KOLB will assist in achieving different pedagogical principles during the teaching process. For example, making conclusions out of the thinking process will lead to encouraging active cognitive processing [9]. While KOLB-based reflection can enhance the feedback's ability to increase knowledge.

The ICAP hypothesis is centered on the student's activities only, it emphasizes that the learning outcomes can be measured and evaluated from the questions asked by the students. ICAP does have a strong relation with cognitive processing by defining cognitive engagement and active learning in ways that can promote deeper learning [10]. ICAP proposed different cognitive modes of engagement (Active, Constructive, Interactive, and Passive). it predicts that interactive activities will support more learning than constructive activities. These additional learning gains are hypothesized to come from increased levels of student engagement [11].

The discussed student-centered hypotheses might influence the learning process by

- Finding differences between active learning and passive learning
- Magnifying the Importance of active learning
- Exploring the role of activation in the learning process
- Justifying the importance of autonomy in engagement
- Proposing multiple methods to apply active learning to a large group of people

1.2. The Introduction to AI course

The introduction to Artificial Intelligence (AI) course aims to give students a broad understanding of the field of AI and how it can be applied. Students will gain knowledge of the historical background and current state of AI, as well as the ethical and societal implications of AI. In this section, we shortly describe methods we utilize in our course (these methods as applied in the freestanding version of the course are described more in depth by Al-Azzawi et al. [12]) to enhance the level of engagement among students. These techniques have been carefully selected to establish an interactive and dynamic learning environment where students are involved in the learning process. These methods aim to encourage critical thinking, active participation, and collaboration among students.

Modular content delivery: Module-based course design is a method of organizing a course into smaller, self-contained units or sections, each of which focuses on a specific topic and has several activities. These modules are typically designed to be completed in a specific order, which can help create a linear learning flow for students.

Flipped e-learning environment: The flipped classroom approach turns traditional teaching on its head. Students prepare for class by watching lectures or reading materials before attending live sessions or classes. This approach allows for more interactive activities during class time, such as group discussions, and teachers facilitate the learning process rather than just delivering information.

Assignments: We used different tools to measure student performance. Quizzes to steer student attention to the main topics of each module and help them identify their strengths and weaknesses. Summary reports for each module outlining their learning outcomes. These reports are then reviewed by a pair of their peers, promoting cooperative learning, and allowing for constructive feedback with efficient use of teaching hours. To facilitate the reviews, a standardized grading tool (system of criteria as rubrics) was provided. Finally, the students receive practical assignment for each module. Some to be solved individually, while others in self-organized groups. For each lab report resulting from these assignments, the students receive feedback from the teaching team.

Practical sessions: Students received help in their practical assignments, both in practical sessions in computer rooms, and in rooms with only blackboards (blackboard sessions). The latter is an excellent opportunity for educators to provide in-depth explanations and work on questions without needing technology. This session encourages face-to-face interactions between teachers and students, leading to a more effective learning experience. Additionally, it allows students to collaborate and discuss with their peers in their groups.

2. Methods

The implementation of the teach-back method had two major elements, namely the concepts students would discuss, and the blackboard sessions where students were engaging in teach-back activity.

2.1. Concepts for teach-back

For each week we followed the schedule below. First, we created a list of concepts we deemed students would find difficult/interesting. Here, one of our goals was to include threshold concepts of the subject. To complement this list of concepts, we also asked students to add to the concept pool. For this, at the start of each lecture, we asked them to note down the concepts they found the most interesting or challenging during the lecture. We collected these notes through a mentimeter poll at the end of each lecture. With this, our goal was two-fold: (i) providing a target for note taking, we wanted to encourage active cognitive processing [10], (ii) increase student motivation by giving them Control [13] over what concepts would be selected for teach-back.

Table 1 Example of how concepts selected were transformed into discussion questions

Concepts identified beforehand by the teaching	Concepts as voted by students at the end of class	Discussion questions distributed before the blackboard session

team		
	Constraint Satisfaction Problem (subject from the week before)	
Difference between the use of frames and ontologies for knowledge representation	Ontological engineering	Difference between the use of frames and ontologies for knowledge representation Limitations of ontologies for knowledge representation
Difference between propositional and predicate logic	Logic Propositional logic Different types of logic	Difference between propositional logic and predicate logic
Difference between inductive and deductive reasoning	Deductive and inductive reasoning are difficult Deductive and inductive How inductive/deductive reasoning connects to AI	Difference between inductive and deductive reasoning
Difference between probabilistic agents and utility-based agents		Difference between probabilistic agents and utility-based agents
What is probability?		What is probability?
What is conditional probability?		What is conditional probability?
	Uncertainties	What sources of uncertainty we can have?
	Fuzzy logic (4 votes)	Fuzzy logic
	Understanding the truth tables Probability calculation I found the Venn diagrams a little hard to really understand Rapidminer	

Lastly, we formulated questions for discussion using the select concepts. Table 1 shows how this process was carried out for materials taught in the 5th week of the course. Where our original questions already covered student inquiries, we kept these questions. In case student inquiries covered new topics, or new aspects of the same topics, we addressed these inquiries with new questions. Lastly, in some cases student inquiries did not need new questions. This was the case when our plan was to cover the subject through different means, or when the subject did not connect to the material of the current week.

When preparing the final list of questions to be shared, our goal was not only to carefully select the topics, but also to word the questions in a way that would be beneficial. That is, for most cases, instead of focusing on individual concepts, we asked students to compare and contrast related concepts, pushing the questions towards higher levels in the cognitive domain of Bloom's taxonomy (understand) than remembering and recalling [14].

2.2. Teach-back in blackboard sessions

We shared the resulting discussion questions with students through the online learning management system, and encouraged them to divide the questions among themselves in their student groups. For most weeks, we provided more questions than the number of students in the groups, so students would have more choice, and could even leave some questions out. We shared these topics at least two days before the blackboard sessions, to give students the opportunity to prepare for the teach-back activity by reading further into their select topic.

As the last pat of blackboard sessions, were encouraged to gather in their groups, and engage in the teach-back activity. That is, explain the various concepts chosen to each other. In this part one teaching assistant (TA) was still present, thus students also had the opportunity to ask their help if questions came up. This way we could provide help to the students while engaging only one TA. The purpose of these sessions were many-fold.

1. By building experience in explaining concepts, students should be better prepared to participate in oral examination, leading to a higher percent of passing grades.
2. By encountering explanations from different perspectives (video materials, lectures, course book, as well as explanation from peers), students should gain a better understanding of the concepts

3. By explaining concepts to their peers, and preparing for these explanations, students should gain a better understanding of the concepts
4. By explaining concepts to their peers, students should find it easier to retain said concepts
5. Preparing for these explanations should increase students' active congitive processing, and student engagement. While student engagement should also be increased if they find the activity they participate in engaging/interesting.
6. Through encouraging students to engage in these discussions about the material, providing them with a low-stakes environment where they can ask the person explaining for clarification without the presence of power imbalance inherent in the student-teacher relation, or the pressure of having a large audience, students should get more comfortable in asking questions.
7. By providing a different way to engage with the course material, we hoped that students would dedicate more time to the course

3. Evaluation and results

To evaluate our implementation of the teach-back method, we used two opportunities, namely the oral exam, and the course evaluation questionnaire. We used the oral exam for evaluation in two ways. For one, we used the opportunity provided by the discussion with students to ask their opinion on the teach-back method, and in general the impression was positive. Secondly, based on our first expectations from Section 2.2 (higher percent of passing grades), we examined the results of oral exams. We found that while before the implementation of teach-back 24.7% of students failed the exam, this year the number decreased to 21.1%. This difference, however, is not significant, and as we introduced multiple changes, it would be difficult to attribute the improvement solely to teach-back. To get a more complete picture of student opinion, we also added questions related to this topic to the annual course evaluation form. We chose the questions based on our further expectations regarding teach-back, as discussed in Section 2.2.

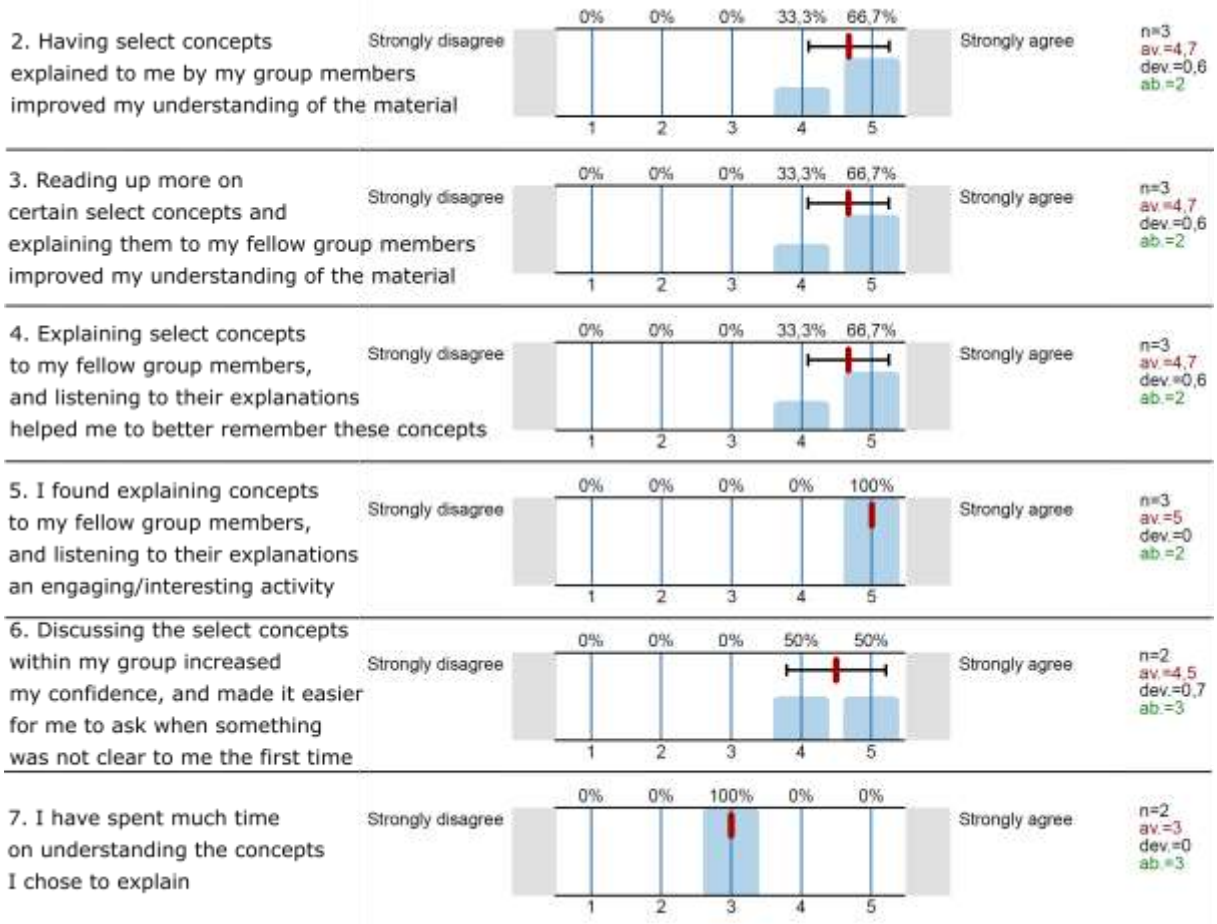

Figure 1 Graphical representation of the course evaluation survey

We share these results with the caveat that few students (6 out of 57) filled out the online evaluation form, and only one of these students engaged in teach-back using the suggested questions. Figure 1 shows the responses for the six questions designed to probe to what extent we reached our set goals (see: hypotheses 2-7 in Section 2.2). As can be seen, the respondents agree or strongly agree that

the teach-back method improved their understanding and their recall of the material. The respondents were, furthermore, unanimous in their strong agreement that teach-back was an engaging/interesting activity. When it comes to the question on their confidence, students agreed, or strongly agreed that it was increased by teach-back. Regarding the question on the time spent, the respondents did not agree or disagree, which we consider to be a fault in the way we formulated the question. It would have been better to ask about the amount of time they used to prepare for giving the explanations, as the concept of "much time" is subjective.

4. Conclusions and future work

Overall, we have seen that when it comes to the oral exam, we had a higher passing rate after the implementation of the teach-back method. Students during our discussions after oral exams expressed positive impressions about the method. These results, while not necessarily significant, are encouraging. We got similarly encouraging, but not definite results from the course evaluation survey. Students who engaged in teach-back found it helpful for understanding and recall, as well as for increasing their confidence to ask questions, and they strongly agreed with teach-back being engaging/interesting. There were, however, very few students who participated in the teach-back, and thus large part of our efforts in future work will be aimed at including more students in this exercise.

One option for future work is to extend the instructions about note taking to the time students spend on watching course videos. Here, we could also ask them to note down the terms they consider key terms for the material. Then, the student teach-back could be extended to key terms as well. Another element we could add to the teach-back topics is the example exam questions we share during the semester. These questions are written in a way that we have a list of potential example exam questions for each week. These questions thus could also be discussed on a weekly basis along with the other concepts. When it comes to including more students in the teach-back exercise, one option could be to make the exercise mandatory for one of the early weeks. This way students would be able to make a better-informed decision about the benefit of these sessions, and whether they would want to continue engaging in them.

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