Nowadays, information is readily available, so people need to develop skills other than the replication of information. This results in a shift of job profiles towards interdisciplinary, ambiguous and creative tasks. Therefore, educational institutions need to evolve in their curricula, especially regarding the compositions of skills and knowledge conveyed. In particular, teaching higher order thinking skills to students, such as critical thinking, collaboration or problem-solving, has become more important. This has already been recognized by the Organization for Economic Co-operation and Development (OECD), which included these skills as a major element of their Learning Framework 2030. One subclass represents the skill of arguing in a structured, reflective and well-formed way. Argumentation is not only an essential part of our daily communication and thinking but also contributes significantly to the competencies of communication, collaboration and problem-solving. Starting with studies by Aristotle, the ability to form convincing arguments is recognized as the foundation for persuading an audience of novel ideas, and it plays a major role in strategic decision-making and analyzing different standpoints, especially with regard to managing digitally enabled organizations. To develop skills such as argumentation, it is of great importance for the individual student to receive continuous feedback throughout their learning journey, also called formative feedback. One of the major challenges is how to provide formative feedback in large-scale lectures effectively, since every student would need a personal tutor to have optimal learning conditions. However, this is naturally restricted by financial resources. One possible path for providing individual feedback is to leverage recent developments in Natural Language Processing and Machine Learning (ML). Researchers use Argumentation Mining (AM) to develop algorithms that extract argumentative components from given texts. This information can be used to score the quality of a text and provide feedback concerning the persuasiveness of a text. Scientists, especially from the fields of educational technology, have designed tools to support the active teaching of argumentation for students with input masks or representational guidelines to enhance students’ learning of argumentation. However, current literature falls short of providing an approach with principles and proof on how to design an adaptive and intelligent IT tool to help students learn how to argue with intelligent formative feedback.

Given this potential for leveraging argumentation mining to enhance learning, we designed and built AL (short for Argumentation Learning), an adaptive learning tool that provides students with feedback on their argumentation structure during their writing process. We followed two different development approaches: a top-down approach, where we systematically analyzed literature in the field of educational technology and pedagogical theories based on and interviewed 30 students with semi-structured interviews to rigorously derive requirements and principles for a first design of AL. Second, we followed a bottom-up approach, where we built low-fidelity prototypes of AL to test different design hypotheses with potential users to learn about the human interaction of an argumentation learning tool. With these two approaches, we present our final version of AL.

To design an individual and adaptive feedback tool, we collected a corpus of 1,000 student peer reviews from our lecture in which students give peers feedback on a digital business model. We wrote an annotation guideline and annotated the texts to build a corpus that fulfills our requirements. Afterwards, we trained a model to classify claims and premises and the discourse of those. This model now serves as the underlying feedback algorithm of AL. To determine the impact of AL on students’ argumentation skills, we evaluated our learning tool in comparison with a carefully designed scripting tool, a proven approach for supporting argumentation in large-scale scenarios. In a study with 54 students, we observed that participants who used AL wrote formally more argumentative texts. Furthermore, the perceived persuasiveness of these texts was significantly higher than of the texts from the alternative tool. We also measured the technology acceptance of of both tools using key constructs. We found that the perceived usefulness and intention to use of AL provides promising results for its usage as a standard learning tool in lectures. The results suggest that AL helps students to write more structured texts and motivates them to write more persuasive texts in peer learning settings, such as peer feedback scenarios.

This work has three main contributions. First, AL is the first intelligent feedback learning tool for argumentation skills. Moreover, we show its effectiveness and usefulness through rigorously comparing AL with the current state of alternative learning tools for argumentation skills. The results demonstrate the benefits of leveraging NLP and ML for intelligent feedback on argumentation in a student’s learning journey. Finally, our results show an exemplary case of supporting meta cognition skills in a scalable and individual way in possible large-scale scenarios. Thus, we provide design knowledge for other researchers and teachers to design and compare similar tools for supporting meta cognition skills of students.