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The Virtual Tutor: Combining Conversational Agents with Learning Analytics to support Formative Assessment in Online Collaborative Learning

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Abstract

The objective of this design science research project is to combine Learning Analytics data with a conversational agent communication interface, the Virtual Tutor, which is able to support formative assessment for educators and learners in online collaborative learning (OCL) environments. The main benefit for educators is providing user-adaptable Learning Analytics data requests to fit the information needs for formative assessment. Learners receive semi-automated feedback on their platform activity in form of reports, which shall trigger self-reflection processes. By extracting requirements from the potential users and deriving design principles, a conversational agent is implemented and evaluated in an online collaborative learning course. The results indicate that the Virtual Tutor reduces the task load of educators, supports formative assessment and gives scaffolded guidance to the learners by reflecting their performance, thus triggering self-reflection processes. This research provides a first step towards data supported (semi-) automated feedback systems for formative assessment in OCL courses.

1. Introduction

In an increasingly digitized and connected world, collaborative online learning is a promising approach to implement modern education using the technological possibilities provided by computer-supported collaborative learning (CSCL). Following social constructivism, the approach verifiably leads to better learning results due to active participation with others, self-determined learning strategies [5] and enables learners to collaborate with international peers [16]. Integration of different knowledge and perspectives is called for in such collaborative settings, leading learners into dialectal argumentation and deeper levels of understanding [2]. During these activities, learners must coordinate with each other and establish common ground to develop mutual understanding through knowledge integration via discussion. This is a complex and demanding process for all parties, which is only successful if guided by skilled teaching staff [10].

Since online collaborative learning (OCL) is on the rise, with continuously increasing enrollment counts in higher education courses [1, 37], educators struggle providing effective and efficient learner support as these settings require an intense amount of oversight [9, 49]. Moreover, learners demand support in their planning and organization of learning processes, their self-assessment possibilities and personalized analyses of their learning activities [42]. Recent studies reveal that in online collaborative learning environments, learning analytics (LA) is suitable to help solve these issues and to adequately support learners and staff in individualized online learning processes [13, 51]. However, despite the data being available, few studies bring visual LA into OCL settings and if so use static visualizations [48]. Additionally, educators have specific information requests depending on the needs of the situation and only providing inflexible LA data is not enough. A suitable solution are Conversational agents (conversational agent), which can represent a user-interface, with which adaptable information request can be processed.

Conversational agents in OCL have been subject to research since the beginning of the 21st century [29]. They are already implemented in various contexts in collaborative and single learning but with content-oriented objectives [20, 23], only few and recent for formative feedback for students not teaching staff [41, 50]. Up until now several propositional publications revolving around the strategies and possibilities of conversational agents and formative feedback in OCL have been completed, [32, 47] but have not been implemented and evaluated solutions in such a context. Furthermore, it is novel to implement conversational agents to support self-reflection processes in OCL.

Consequently, a research gap with practical relevance is the support of teaching staff and the learners

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themselves by using the combination of LA and conversational agent technology to provide formative feedback to educators and learners. The conversational agent shall have two main functionalities: 1) Teaching staff shall be able to access the LA with the conversational agent in a convenient and flexible manner, and 2) the conversational agent shall act as a communication interface with the learners to inform them of their performance in the collaborative setting and to point out potential for guidance and improvement.

In order to address this research gap, a LA communication interface for educators, the Virtual Tutor, is designed and implemented. This Virtual Tutor interface shall support the educators in their pursuit to provide meaningful guidance and oversight of learners using the provided social LA data. Furthermore, learners' data is fed back to the learners themselves using the interface to help with self-organization and trigger self-reflection processes. To achieve the goal of supporting educators and providing formative feedback to learners, a design science research approach was chosen [22]. Using the relevant scientific preliminary literature and group interviews with teaching staff, requirements are extracted and design principles for the Virtual Tutor are derived. Based on these principles the software artifact is designed and implemented into an OCL environment. Finally, teaching staff and learners evaluated the Virtual Tutor, regarding perceived usefulness and degree of approval based on the derived design principles. This procedure shall answer the following questions:

RQ1: Which requirements and design principles have to be considered, when designing a conversational agent to provide formative feedback to educators and help learners organize and self-reflect on their performance?

RQ2: How do educators and learners assess the benefit of the Virtual Tutor based on the developed design principles?

The remainder of the paper is structured as follows. First, a short introduction into the background and related works is presented. Second, the methodology is described in detail. Afterwards, insight is given into the derivation of the design principles and the implementation of the Virtual Tutor. Finally, the results of the evaluation are presented as well as implications drawn, whilst explaining paths for future research.

2. Background and related works

2.1. Online collaborative learning and e-tutors

Online collaborative learning is group-based, communication-driven learning, which integrates synchronous as well as asynchronous communication within an online collaborative learning environment [39]. The learner shall use the online collaboration tools available in the environment, e.g. Microsoft Teams, to enable spatially separated group work. During the development of a solution, the students research information, discuss their findings on the collaboration platform and produce viable results [21]. Furthermore, the framework remains learning content independent and is therefore widely applicable as long as the tasks given to the learners involve collaboration.

Social Constructivism fosters high-level knowledge-construction as learners discuss contrasting ideas and pose each other questions, which brings up insufficient understanding or confusion about the topics in focus. These identified gaps are then targeted accordingly to generate an advance in knowledge [16, 17]. Furthermore, a high degree of self-responsibility and organization is required as learners are responsible for the timely progress and results of their work. They are supported and guided in their work by qualified teaching staff or the e-tutors to maximize individual and group learning success [30]. Therefore, the observation and support of learners regarding their interaction behavior and presence as well as their participation must be considered a key task of e-tutors.

Guidance theory in OCL is first discussed in Eryilmaz et al. (2018), which focused on an attention-guidance system, to influence attention on task-relevant information in online collaborative literature processing [16]. Attention guidance can be defined as "the use of cues and signals to focus attention to important content" [8]. These cues and signals can be used to attract, retain or reacquire attention on central elements of the OCL process. There are two forms of guidance, which can improve learning outcomes: scaffolded guidance and peer-to-peer guidance [16].

E-tutors use the scaffolded guidance to provide meaningful learner support, necessary for successful online collaborative learning [18, 19]. In particular, e-tutors are essential for both learner observation and formative assessment. Implementing formative assessment has a significant influence on the learning and teaching process. It includes all activities of the teacher and/or learner that provide information that can be used as feedback, to modify learning and teaching activities [40]. Formative assessment and feedback has proven to empower students as self-regulated learners and plays a central role in increasing motivation and self-esteem [33, 46]. The aim is to analyze and respond to the activities of learners to improve the learning process [12].

Within the course, the e-tutors operate as learning facilitators accompanying groups and performing a range of tasks from functional support and personalized individual and group support over technical support to organizational assistance. In order to give in-depth feedback to learners, especially while engaging in individual and group support, e-tutors need to analyze the interaction behavior between learners adaptively. This is currently driven by the manual inspection of communication data inside the OCL environment. The resulting high workload restricts the e-tutor in supervision capacity as well as in identifying potential problems and early resolution [11].

2.2. Learning Analytics and Conversational Agents

LA can be used to increase the quality of learner support and to reduce the overall task load of e-tutors by partly automatizing the scaffolding guidance [30]. It enables teaching staff to "access, elicit, and analyze the generated data of learners for modelling, prediction, and optimization of learning processes" [31]. There are different approaches for LA data analysis. For instance online analytical processing (OLAP) and dashboards have been implemented [30, 35, 44] in the context of LA. However, both struggle with acceptance. OLAP requires additional technological skills and a deep understanding of the underlying data structure. Dashboards, on the other hand, are often not flexible enough for the necessary analyses required by the teaching staff. A different approach is the combination of LA and conversational agents, which can represent a user-interface with which adaptable LA information requests can be made.

Conversational agents are messenger-like agents that use chat interfaces to communicate with the user. These intelligent data supported learning systems have shown to improve learning processes, also in OCL [24, 27]. Conversational agents in OCL have been subject to research since the beginning of the 21st century but the possibilities for conversational agent in OCL evolved significantly since then [25, 29, 45]. Kumar and Rosé [29] describe tutorial dialog systems aimed to deliver instructional content in multiple learner settings. Hayashi [20] and Hobert [23] focus on content-specific learning support in paired or group learning. Several publications discuss conversational agents aiding collaborative software development either to enhance programming skills or soft skills while programming [6, 34]. Giving formative feedback by conversational agent in OCL based on learners' activity data has been proposed [32, 47] but not implemented and evaluated in an OCL context.

3. Research Design

In this research project, a design science research approach [22] is used, which has been proven successful in similar research, regarding the derivation of design principles through the conceptualization and implementation of a software artifact, as explained in detail below [23, 38, 52].

In the first step, two group interviews with five e-tutors with different levels of experience, ranging from half a year to multiple years of tutoring as well as three course instructors, who hosted different variants of online collaborative learning courses, were conducted. Within the interviews, a more concrete understanding of the exact problem statement concerning the complexity of the e-tutors' work was gained. Furthermore, a comprehensive overview of the tasks of e-tutors and their expectations on how they could be assisted by a conversational agent, which provides access to LA methods, was compiled.

In the second step, the knowledge base regarding possible requirements and beneficial designs concerning conversational agents in this particular OCL setting was analyzed. A set of requirements for a corresponding software solution was extracted by taking into consideration both theoretical aspects as well as the derived use cases regarding the problem statement.

In the third step, design principles were derived based on the set of requirements. By aggregating the requirements and abstracting of any platform- and implementation-specific aspects 4 design principles are established. Within the fourth step, a corresponding software artifact, the Virtual Tutor, was designed based on the design principles and with regard to the developed requirements.

In the fifth step, the first version of the conversational agent was implemented using the previously created design principles as well as preexisting technological resources. These resources contained a self-developed LA data warehouse, as well as the in use online collaboration platform. E-tutors were able to interact with the conversational agent, in order to flexibly access LA data and partially automate reoccurring tasks of their work. During this period (step 6), weekly reoccurring evaluation took place via questionnaires. Through the feedback derived by the questionnaires, the software artifact was incrementally adapted (step 7) to improve the e-tutor support as well as the fit between the created requirements and the implemented software.

In the eighth step, a final, more comprehensive, questionnaire with both e-tutors and learners was conducted. The following aspects were examined:

I. The perceived usefulness of the conversational agent for the reduction of the e-tutors' task load.
II. The degree of approval regarding the fulfillment of the design principles of the created software
III. The degree in which each of the stated design principles was essential for the reduction of task load

Finally, the knowledge base was extended through the documentation of the derived design principles in this publication (step 9).

4. Design, Development and Evaluation

This chapter is structured along the previously described steps.

4.1. Extraction of the exact problem statement and use cases

To gain a deeper understanding of the complexity of the task load of e-tutors as well as the environment (relevance), group interviews with experts, as mentioned in the previous chapter were conducted. Both group interviews were carried out in an identical manner by asking the e-tutors the following questions:

I. How would you describe the typical daily tasks of as an e-tutor?
II. Could you give examples of reoccurring tasks, which you perceive as repetitive?
III. Which of these tasks could benefit from a simplified access to information about the learners of online collaborative learning projects?
IV. Which additional tasks and measures would increase the quality of learner support?
V. How can these tasks and measures be enabled?
VI. Which tasks cause problems on a regular basis?
VII. How could a conversational agent (chatbot) lead to an increased efficiency in the e-tutors' work, possibly resulting in the ability to support more learners or increase the quality of formative feedback?

These discussions were transcribed and analyzed, in order to extract use cases. The following use cases are from the perspective of e-tutors (T#), as well as from the perceived expectations of learners, as communicated towards the e-tutors beforehand (L#):

T1. As an e-tutor, I want to evaluate the activity of my groups of learners effectively.
T2. I want to analyze and compare the activity of learners based on automatically aggregated data.
T3. I want to be able to evaluate the coordination behavior of my groups of learners.
T4. I want to be notified if some of my groups fail to submit their assignments in time.
L1. As a learner, I want to be informed about new tasks.
L2. I want to be notified if my group submitted a task successfully.
L3. I want to be provided with information about upcoming events.
L4. I want feedback on collaboration activities as well as ways to improve my collaboration activities.
L5. I want to receive global announcements in a central channel of the collaboration platform.
L6. I want to receive activity reports of my learner group on a regular basis in order to compare our activity with the average of groups.

4.2. Derivation of requirements from the environment and knowledge base

The need for an effective analytics interface (T1-T3) on the one hand and on the other the stated performance advantages resulting from the use of conversational agents, as described in the knowledge base, led to the formulation of the first requirement: Provision of a natural-language-based interface for e-tutors (**R1**).

In order to increase the effectiveness of the e-tutors' work, the provision of information about the learners' activity/interaction behavior (**R2**) is a second central requirement. Besides that, it was discovered that another main source of e-tutors' high task load is the unidirectional provision of general information, such as task definitions and announcements within all of their assigned groups (L1, L3, L5). Therefore, the provision of information to all learners via a central interface (**R3**) would decrease the time needed by e-tutors to deliver information.

A further task of e-tutors is to give formative feedback and motivate collaboration activities of learners (L4) to foster social presence and interaction of the learners. This led to the requirement to ensure the provision of context sensitive formative cues to the learners (**R4**).

In contrast to e-tutors needing flexible analysis of learners' activity and interaction data, learners only need the information about their activities in a useful form (L4,L6). Therefore, the following requirement was derived: provision of unidirectional formative feedback to the learners (**R5**). Furthermore, it was possible to identify the interaction data of learners as a key source of information for formative feedback for both e-tutors as well as learners (T1-T4, L4, L6).

Finally, there is the possibility of proactive notification of e-tutors, e.g. in case of missed submissions by their assigned groups (T4) as another potential to improve their efficiency and reaction time on incidents. This leads to the last requirement: Provision of context sensitive notifications to the e-tutors (**R6**).

4.3. Derivation of design principles

Although the concluded requirements lead to a deeper understanding of possible solutions within the particular problem, they are too specific for an implementation in any OCL environments and to provide added value for the research problem in general. Therefore, design principles were derived as an abstraction of the requirements (Figure 1).

The first design principle emphasizes the approach of a natural-language analytical interface for teaching staff as described in R1 (**DP1**). Further, the principle of support of formative assessment by the supply of activity data (**DP2**) was deduced, which is necessary for implementation-specific analytics like R1, R4 and R6. The third design principal abstracts from R3 and R5, by concluding that automated, semi-adaptive and natural language notifications should be provided to the learners (**DP3**). The last design principle results in a commonality of R2 and R4, stating that it is beneficial to provide automated feedback of learner's behavior for self-reflection (**DP4**).

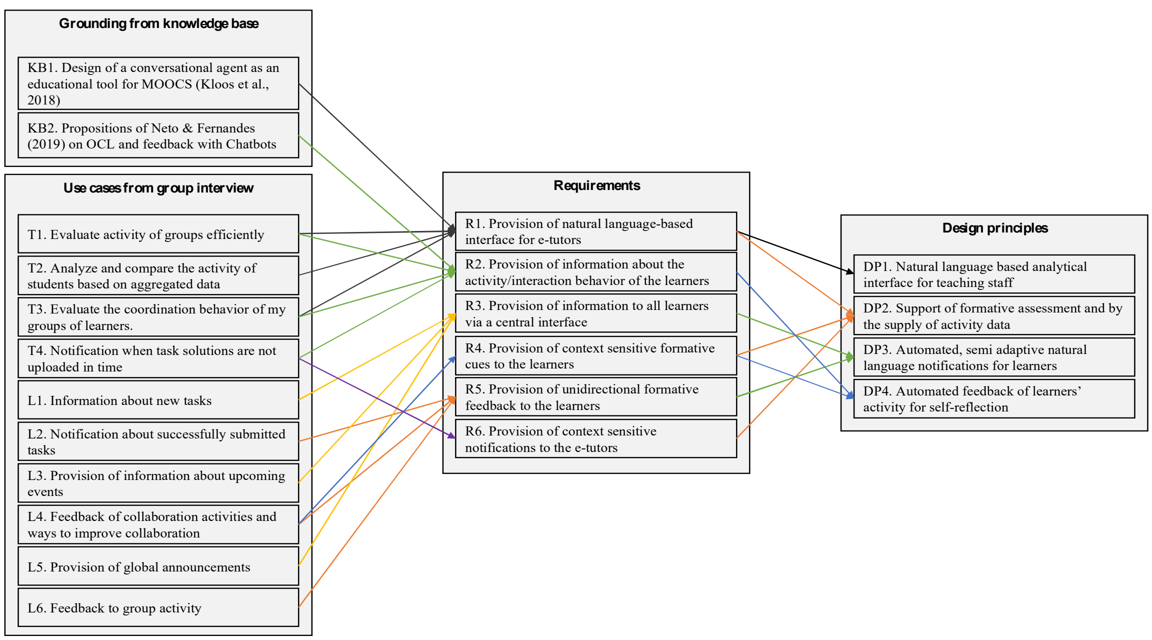

Figure 1. Visualization of the derivation process towards design principles

4.4. Design of the software artifact

With regard to the design principles and derived requirements, the Virtual Tutor conversational agent was designed, which shall be demonstrated in an exemplary online collaborative course. The interaction with the software artifact should provide the e-tutors with insights into the learners' data, based on natural-language requests (R1, DP1, DP2). These requests are adaptable in activity type (e.g. messages, posts, likes), selected groups/learners and timeframe (e.g. days, weeks). The visualization is then generated depending on the parameters given to the conversational agent by the e-tutors. Since the identified use cases for the conversational agent towards the learners turned out to be unidirectional informative, the interface is implemented as read-only for learners and delivers reports of learners' activity as well as context-sensitive cues and relevant pieces of information to the learners' group channels within the collaboration platform (R3, R4, R5, DP3, DP4).

4.5. Implementation of the software artifact

In order to implement the software artifact, an iterative approach, similar to SCRUM, was chosen [3, 43]. This enabled an implementation of the core structure and basic functions of the artifact in a first run

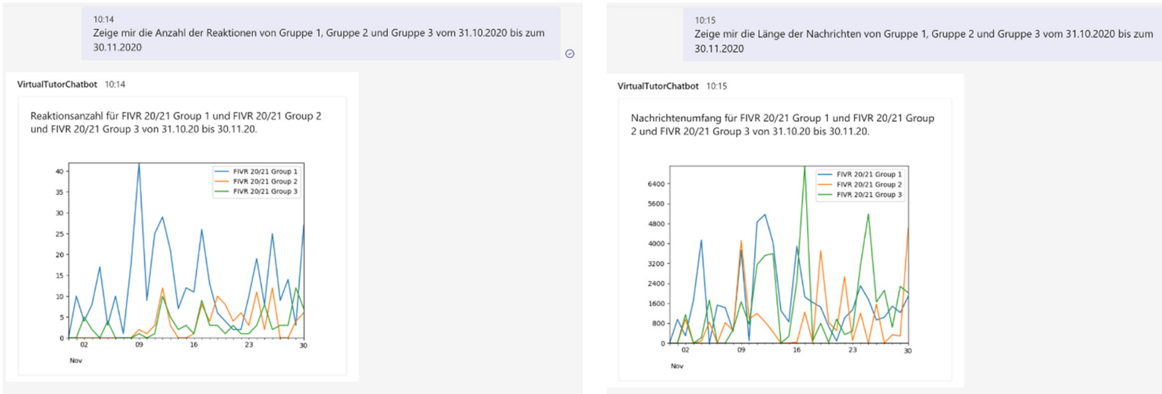

Figure 2. Implemented chatbot interface with LA requests

while advancing the functionality based on the users' experiences in further stages of the research. Since the artifact relies on activity data derived from the social collaboration platform, an interface based on a self-developed data warehouse was implemented, which uses techniques of educational data mining as well as interfaces to Microsoft Graph to acquire the necessary data for LA evaluations (R2, R4, R6, DP2 and DP4). This provided significant performance advantages, in contrast to the push request access to the data via the Microsoft Graph API. However, it must be noted that this additional aggregation instance comes at the cost of real-time evaluation since the data warehouse does only provide data, which was available until the previous morning. Concerning the implementation of the natural-language interface for the e-tutors, a chatbot was implemented in the collaboration platform using the Microsoft Bot Framework [4]. The backend component of the chatbot is designed based on common patterns of chatbot design [7, 15, 36].

The depicted frontend of the conversational agent's natural-language interface accepts chat messages as input (DP1) and reacts according to the discovered intent. Furthermore, the conversational interface plots the requested data in a chart in order to provide support for the e-tutors tasks, e.g. formative assessment, by supplying activity data (DP2). This is illustrated in figure 2, in which two different datatypes are requested, reactions and messages for different groups.

Figure 3 displays an excerpt of a formative report, which was provided to learners of the online collaborative learning project. To give learners guidance for the interpretation of the reported data, automated semi-adaptive descriptions were given within the notification (DP3), e.g. "the total length of your posts and comments was higher than the average of the groups". This report serves as feedback for the learners within the project by describing itself as well as the learners' activity data within a set of diagrams (DP4).

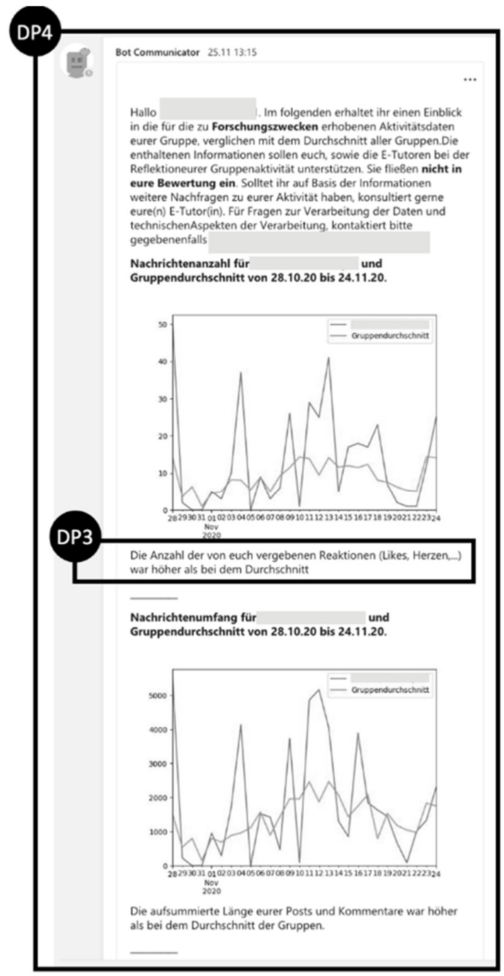

Figure 3. Excerpt of a semi-automated formative report

4.6. Reoccurring evaluation of the software artifact

As mentioned in the chapter "research method", a laboratory test was conducted for the created software artifact within an online collaborative learning project. This project took place during the winter term of 2020. In total 73 participants within 12 groups were involved. The artifact provided three feedback reports to every participating group within the semester term. Furthermore, the four involved e-tutors answered the following questions on a weekly basis:

I. Does the provided functionality of the software artifact meet your expectations? If not, which features should be adapted?
II. Did you experience difficulties or find errors in the behavior of the conversational agent?
III. Do you see new potential features or improvements, which the tool should provide in the future in order to provide higher supportive value?

Accordingly, a series of requests for improvements and new features as well as error reports were collected from the e-tutors. The requests were prioritized regarding the degree of change, that would be necessary for their fulfillment as well as the subjective benefit. Regarding the error reports, the reported error situations were replicated and corresponding fixes were implemented ad hoc.

4.7. Incremental adaption of the software artifact

Based on the previously derived change requests the respective feature requests were implemented based on the feasibility and benefit of the changes, e.g. changes regarding the chart's adaptability within the reports during sprints of two weeks. Concerning major changes, two were implemented: more options for temporal aggregation of the data and further visualization options to compare groups directly.

4.8. Final evaluation of the software artifact

To evaluate the Virtual Tutor, two questionnaires were given at the end of the course, one to the e-tutors and another to the learners. The included questions examined the usefulness and ease of use of the implemented design principles according to the Evaluation of function and form constructs, formulated by Davis (1989).

The learners' questionnaire consequently focused on DP3 and DP4, whereas the e-tutors' questionnaire evaluated DP1, DP2 and DP4. The quantitative questionnaire items were based on a 4-point Likert scale (1: strongly disagree to 4: strongly agree), so that students must decide between positive or negative outcomes [28]. The Cronbach Alpha for the survey of 73 participants was 0.82. Averages were calculated for all items and aggregated to the respective design principle. Furthermore, the e-tutors were asked if they consider the Virtual Tutor suitable for practical use in OCL environments and if they intend to use it in the future again based on a 4-pont Likert Scale. At the end of the evaluation all 4 e-tutors and 73 participants returned valid questionnaires, which are the basis of the analysis.

The results show that e-tutors and learners evaluated the design principles as useful and easy to use (see Figure 5). Therefore successfully partly automatizing scaffolded guidance. None of the e-tutors or learners rated the design principles lower than 2. DP1 (Natural language based analytics interface) was rated on average with 3.25 in function and 3 in form, which indicates that the flexible user interface was a functional gateway to formulate information requests with potential for improvement. DP2 (support of formative assessment by the supply of activity data) was evaluated with an average of 3.75, which points towards that the

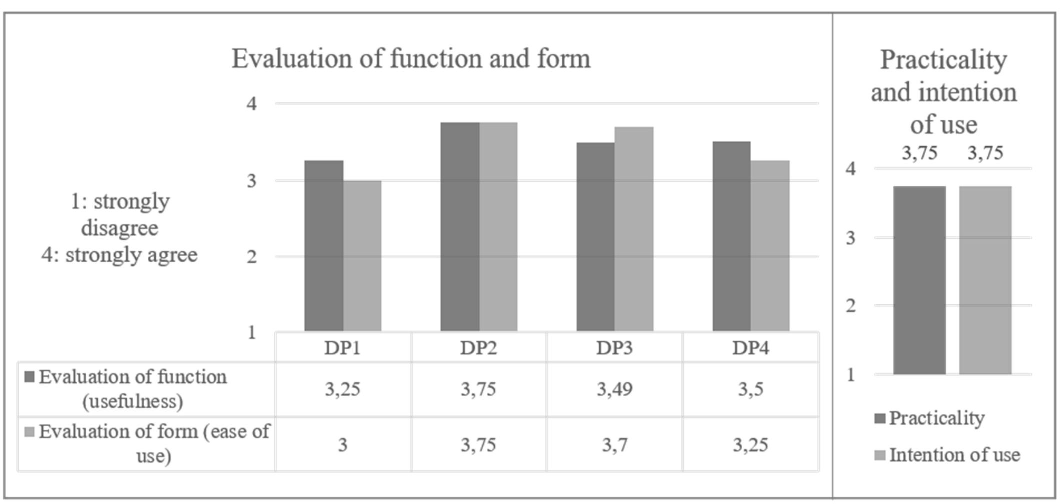

Figure 4. Evaluation of design principles, practicality and intention of use

generated learning analytics dashboards were helpful in satisfying information needs of the e-tutors. Furthermore, the evaluation of DP3 (semi-adaptive and natural language notifications provided for learners) with 3.49 in function and 3.5 in form and DP4 (automated feedback of learner's behavior) with 3.5 in form and 3.25 in function showed that learners valued the obtained feedback. The evaluation of practicality and intention of use indicates that the Virtual Tutor effectively supported the e-tutors in their tasks regarding formative assessment and provided adaptable insights in the activity of learners.

In addition to these quantitative items, e-tutors and learners had the possibility to provide written feedback, e.g., required improvements and further remarks. The written feedback by the e-tutors confirmed the successful support of formative assessment and reduction of the e-tutors task load. One e-tutor stated, "I consider the chatbot to be a very helpful companion to the expansion of formative assessment." Another wrote, "The tool has really helped me with the quantitative evaluation of the communication and has taken a lot of work off my hands!" Learners stated that they liked the comparison between groups to assess their performance and their potential for improvement. However, participants also discussed weaknesses, as the analysis does not incorporate all aspects of the collaboration platform yet (e.g. meetings/calls). This aspect can only be implemented when the API of the platform allows access to these data types. Furthermore, the written analysis could have included more concrete aspects on how to improve performance, according to learners.

In summary, the evaluation of the Virtual Tutor shows that the conceptual design and the design principles are valid for using a chatbot-based communication interface to support e-tutors in their tasks and learners in self-reflecting their performance. E-tutors as well as learners rated both, the form and the function, of the implemented design principles as suitable. As the availability in data types increases, the analysis of the activity can give a more complete overview, which will be part of a continuous improvement process.

4.9. Documentation of design knowledge

Finally, the knowledge base was extended through the documentation of the derived design knowledge in this publication. Gregor and Jones (2007) formulated 6 components to document design knowledge: Purpose and scope, constructs, principles of form and function (DPs), artifact mutability, testable propositions and justificatory knowledge. As the first three components and the justificatory knowledge in form of the knowledge base were already described in detail in chapters 1,2 and 4, artifact mutability and testable propositions are detailed here. Artifact mutability: the Virtual Tutor, can be applied in every online collaborative learning environment independently of a specific course content. Testable propositions: to test the design principles and implementation, each aspect needs to be surveyed. To evaluate the effects on e-tutors formative assessment performance, the following propositions should be considered: (1) Using the Virtual Tutor increases the e-tutors ability to formatively assess online collaboration. (2) Using the Virtual Tutor improves the provision of guidance for participants. (3) Using the Virtual Tutor increases the e-tutors capacity to concentrate on content-related issues rather than organizational questions. (4) For participants, the Virtual Tutor triggers self-reflection processes to improve the participants' performance in the course.

5. Discussion and Conclusion

The aim of this design science research project was to design a conversational agent communication interface, the Virtual Tutor, to support e-tutors in their tasks, especially formative assessment, as well as help learners self-reflect on their performance and thus semi-automatize scaffolded guidance. In particular, the goal was to provide e-tutors with activity/interaction data to compare group and individual performance with a user-oriented adaptable analysis interface. To achieve these objectives, requirements were derived from expert interviews with e-tutors and the scientific knowledge base. Based on these inputs for relevance (expert interviews) and rigor (knowledge base), design principles were deduced and the software artifact was implemented in a productive OCL environment. The functionality and ease of use of the Virtual Tutor was iteratively improved, similar to SCRUM, by collecting weekly improvement requests from the e-tutors and implementing them ad hoc. After the course was finished, the Virtual Tutor was evaluated according to the design principles by e-tutors and learners, proving that the implemented design principles and the Virtual Tutor itself are effective in supporting the e-tutors with their tasks and help learners, assess their performance in the course.

In addition to the software artifact being an effective user-oriented communication interface for OCL environments, design knowledge is added to the scientific knowledge base. Design principles are systematically deduced from collected requirements and implemented for a proof of concept. The resulting design knowledge is not only valid for the specific case but can also be applied in every other OCL setting in education. Because of the transferability of the design knowledge, this research does not only provide a Level

1 DSR contribution by showing a situated artifact implementation but also provides a nascent design theory (Level 2), as it successfully integrates scaffolded guidance in a semi-automatic response system in OCL [26].

Besides the scientific contribution, the research shows that the combination of LA methods with chatbot-based technology is a promising approach to support decision making in online collaborative learning settings to manage this environment effectively. This means e-tutors in education can use this approach to make the complex platforms more controllable with less effort.

Despite these contributions to the scientific knowledge base and the practical application of the Virtual Tutor, limitations should be considered. The available LA data does not display all activities happening on the collaboration platform as some data types are not yet retrievable from the database. In addition, the pedagogical advice connected to the LA data needs to be enhanced with concrete recommendations for action. Furthermore, the Virtual Tutor can be enhanced to represent an interactive FAQ module, which is merely a content addition but should substantially help disencumbering the e-tutor further.

For future research, the data should be used to trigger a (semi-)automatic pedagogical response, recommendations for actions or even action requests for e-tutors as well as learners. This would enhance the formative assessment as interventions are directly communicated to the person connected to the intervention. Another analysis implementable in a conversational agent could be discourse analysis of the groups. The conversational agent could analyse how on track the groups are depending on their contributions and tasks. Furthermore, the effect of feeding back data to learners and the degree of self-reflection and behavioral change is a causal chain, which should be investigated in more depth in the future.

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