ConceptCloud: Supporting Reflection in the Online Learning Environment Go-Lab

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Abstract: Heterogeneous online learning environments such as Go-Lab foster student-centered and exploratory STEM education through the promotion of Inquiry Learning. Although the learner is encouraged to create learning objects such as concept maps or hypotheses, the interpretation and reflection on them is complicated by differences in their form of representation. This work presents the ConceptCloud app which aggregates learner-generated textual objects by constructing a tag cloud visualization and simplifying reflective processes. In order to validate this approach, a user study examines the app in a classroom scenario. The results reveal a low involvement of the ConceptCloud in the learning process, which might indicate the necessity of more guidance to increase learners engagement and awareness of the app. The teachers perspective is received positively, since they felt supported in supervising students activities and facilitating a teacher-led inquiry approach trough usage of the CC.

Keywords: Inquiry-based Learning, Content Analysis, Reflection, Artifact Visualization, Teacher-led Inquiry

1 Introduction

The European project Go-Lab implements the idea of an interactive science education by shifting from a teacher to a student-centered learning scenario. It offers students to explore the learning contents by experimenting with online laboratories and combines classroom activities with in-class online learning as well as provides teachers with facilities for customized learning spaces [dJSG14]. The spaces are organized as subsequent phases promoted in Inquiry-based Learning (IBL) [PMS15] and can be enriched with virtual and remote laboratories to promote inquiry skills and a better conceptual knowledge [dJSG14]. In addition, Inquiry Learning Applications (apps) support the students in the creation of textual learning objects such as wiki articles or concept maps. Due to its heterogeneity, the interpretation of learner-generated content is challenging and underlines the need of an aggregated representation. The ConceptCloud (CC) presented in this work has the goal to generate a single tag cloud representation from the textual artifacts to support students and teachers in getting an overview of the generated contents and recognizing insufficiencies by offering the possibility to compare themselves to the class. In order to evaluate the system, a user study is performed to examine the CC in class.

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2 Inquiry-Based Learning and Learning Analytics

Go-Lab provides teachers a recommended Learning Cycle realized through customized Inquiry Learning Spaces (ILS), a frame to distribute learning materials and scaffolds [dJSG14]. The pedagogical structure aims on encouraging students to develop questions, state hypotheses, design experiments, and reflect on the observations [PMS15]. In this context reflection is defined as a cognitive process executed to learn from experience [Mo04]. Scaffolds are provided through tools in Go-Lab, which enable the learners to create artifacts as externalization of their knowledge structures [ODH02]. Those scaffolds guide through the IBL process supporting learners [dJSG14], fostering critical thinking and 21st century skills [WYW08].
Beyond the empirical analysis of learning interactions, the field of Learning Analytics (LA) makes use of computational approaches and adapted methods including analytics of content, processes, and (social) network structures. The analysis of learning processes following a model of learning phases in IBL has been applied using methods of sequential pattern analysis [MCRT15]. Content-based analyses have so far received less explicit attention from a LA perspective. The OpenEssayist-System [WTR15] analyses learner-generated text-based artifacts using linguistic approaches by inducing a way to write ”good” essays through an underlying reference model. Although the system adapts to the learners in their production of content, it lacks support in the interpretation of the outcomes. Thus, the revision of those might be supported effectively through the (automatic) processing of learner-generated content with LA applications. On the one hand, the different types of methods come with different requirements. On the other hand, the combination and synergistic use of different methods is desirable but constitutes new challenges from a conceptual as well as a computational point of view.
Several systems already represent knowledge using semantic technologies as through Natural Language Processing to identify rhetorical functions of sentences (cf. Xerox Incremental Parser (XIP) Dashboard). This Dashboard visualizes analytics as aggregated salient sentences of scholarly papers [SSDL14].
To effectively provide scaffolds for the interaction with learner-generated content, Wise, supplemented by Harrer et al., stated the design principles of LA interventions. An intervention can be defined as a frame to use analytic tools and gather data. The CC is designed along these principles as further explained in the following section [Wi14, HG15].

3 ConceptCloud Approach

The CC is an application to aggregate the learners' textual artifacts, like wiki articles or concept maps, through vocabulary extraction by semantic analysis. This learner-specific set of terms is drawn up automatically from their textual artifacts containing all relevant concepts the learner has used. Those concepts are key terms which are essential to understand a specific topic. Figure 1 shows the application's scheme of processing artifacts with the resulting aggregated model of all concepts extracted and visualized in the CC. Go-Lab includes tools for the creation of learning objects across different ILS phases, e.g., a concept mapper, a hypotheses scratchpad, or a wiki authoring tool. The first two require the learner to enter isolated concepts, whereas the wiki tool anticipates continuous text.

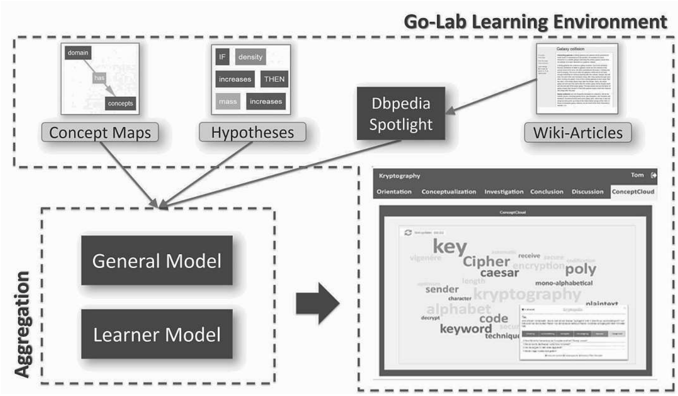

Fig. 1: The processing of learner-generated artifacts and the resulting CC visualization.

Therefore, the vocabulary extraction from concept maps and hypotheses is done by filtering keywords, whereas wiki articles demand a pre-processing. For this purpose, the functionalities of DBpedia Spotlight [DB15] are used to filter relevant concepts from wiki articles by using an extensive ontology and automated text analysis. After the learners have finished a task using one of the tools, their maps, articles and hypotheses are forwarded to an analytics component which normalizes all concepts appearing in the artifacts and traces them back to the underlying semantic concepts with the methods explained above. All concepts are annotated with additional meta data and include a time-stamp, an identifier of the ILS, and the occurrence frequency of the concept. They are represented in two models: (1) learner-related, including concepts used by an individual student, stored with information on the corresponding ILS phase and the app a concept was used in, and (2) general model, emphasizing vocabulary-related information as the number of learners who used it in a specific app or the overall occurrence frequency.

Therefore, the visualization of the CC for the learner is mainly influenced by the occurrence frequency. The more frequently a concept is used by all students, the larger it is displayed. In addition, the color of the concept is set depending on the student's individual usage of a concept: green - a concept was used in all possible learning phases; red - a concept was not used at all by a student; yellow - a concept was used in one or more phases, but not in all phases. To provide the students with further support, they can select a concept per mouseclick, receiving a pop-up with further information on its purpose. The teachers are able to view all student models, browse through them, and apply filters for artifact types and/or phases. When selecting learners, deviating students are highlighted.

As described in section 2, the CC is designed along the principles of Wise and Harrer et al. [Wi14, HG15]. The aggregated results are included in the learning environment as separate ILS phase to support the *Integration*, provide scaffolds for the interpretation of results (*Agency*), enable comparison through the inclusion of concepts not used by the individual but by other students in class (*Reference Frame*), and give the learners a chance to review and revise their entries based on the analytics results (*Dialogue*). Moreover, the CC filters only relevant concepts the learners used in their artifacts (*Scope*) and is visualized in a neutral look and feel so that it adapts to every ILS created (*Representation Consistency*).

4 Evaluation Design and Results

The study aims to explore whether the CC supports the students' reflective processes during a learning activity. A triangulation approach is used which combines methods for gathering performance and behavioral data as an indicator for students' reflective processes. A classroom experiment was conducted in a computer science class at a German secondary school covering the topic of encryption. It included fifteen male students (16 - 18 years), of which nobody had worked with Go-Lab before. The students passed five IBL phases, created four wiki articles, one concept map and a set of hypotheses. The class was split up into control (n=7) and experimental group (n=8), whereof the latter had the CC included in the ILS as separate phase as well as in the first phase to call their attention.
We assume that students using the CC (1) gain a higher score in a knowledge test on encryption, (2) create better learning objects, and (3) show different behavioral patterns, e.g., a higher rate of artifact revisions, due to enhanced reflection on the learning content. The following section describes the methods and results of the study.

A pre and post knowledge test on encryption was performed checking pre-knowledge and knowledge gain, containing seven questions scored with 14 points in total. None of the students had prior knowledge in encryption methods. The post-knowledge test showed an average knowledge gain of 72% (*average score* = 7.9) in the experimental group and 76% (*average score* = 9.0) in the control group. The learning objects were scored using a model solution. The students gained one point for each consistent concept with the model solution and one additional point for formal aspects (text structure etc.). Students of the experimental group gained an average score of 4.7 out of 6 possible points for their wiki articles. The control groups' wiki articles were scored 4.1 on average. The average score of concept maps was 6.4 out of 14 points for the experimental and 6.9 for the control group. No plausible relations could be identified between students performance and action patterns. The log files gathered from the students' interaction with the ILS include creation and revision processes of learning objects and interactions with the CC (click on a concept or viewing the CC phase). As visualized in figure 2, seven students in the experimental group made use of the CC, whereof only two used it at the end of the learning process (S3 & S7). As expected, revisions of existing learning objects, mostly hypotheses, take place right after interacting with the CC. However, in total, there are very few revisions of learning objects in the experimental group. Although the students had two lessons to finish the ILS, seven students did not finish their artifacts.
A qualitative questionnaire indicates difficulties in interpreting several visualization aspects of the CC. Uncertainty mainly occurs in understanding the colouring scheme of the concepts. Additionally, two interviews were conducted in order to gain insight in the teachers' thoughts on the CC. Both teachers, having used Go-Lab and the CC in class themselves, consider it an useful instrument for supervising the students' performance and student-centered organization of learning activities. However, as a negative aspect, the visualization of artifacts without relations was mentioned. Summarizing the results, early indications for a support of the learners' reflective processes through the CC can be found. Although the analysis of the users' artifacts and the examination of their action sequences suggest only weak differences between the groups, initial attempts of reviewing and revising learning objects can be found.

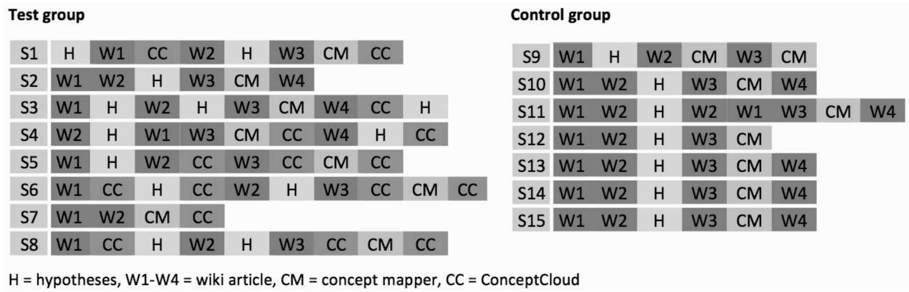

Fig. 2: Action sequences per student for experimental group (S1-8) and control group (S9-15).

Reflection and meta-reflection as mental constructs are of course not easy to attest. In the context of self-regulated learning it is proposed to measure reflection through a combined approach of students' performance and artifacts [SB06]. This is accomplished by evaluating both the students' learning objects and their behavioral data, which worked as a good resource to get an impression of the learning outcome. Future studies could additionally take into account students' subjective perception of their reflective processes. The ambiguities in the action sequences however uncover a lack of purpose when using the CC. The students do not seem to understand what the CC could do for them. Thus, further guidance is necessary to foster awareness as well as a more continuous and intense engagement in using the application. A promising approach could be the linkage of the CC to classroom-related or curricular issues, leading to a more active integration into the learning activity supporting the lessons' overall goal.
In contrast to the ambiguous results of the students, the teacher interviews show a clearly positive perception. The CC works as a promising support of *teacher-led inquiry into student learning (TISL)*, an approach that shifts the teacher's role towards a more practically oriented one in which teaching itself is perceived an experiment that should be improved continuously [CLJ11]. In this context, the CC can be used to monitor student knowledge and, as a consequence, to reflect upon own teaching practises.

5 Conclusion and Future Work

The CC presented in this work is an application supporting successful and independent science education in Go-Lab. By aggregating and visualizing the learner-generated content, the CC aims on encouraging students' reflective processes and the teachers' supervision. The results of the study revealed a need for interface improvements and further guidance. Prompts could be used to foster self-regulated learning by visualizing major changes in a learners' CC and shifting their attention towards certain yet unused concepts [dJL14]. Moreover, the embedding of the CC as last phase of the ILS should be reconsidered, taking into account the lack of time for important reflective processes at the end of the learning scenario. Therefore, future studies should implement a longer time span for tasks and reflection, which could result in learning artifacts of higher quality. Still, the teacher interviews pointed out the benefits of supporting the supervision of the learners' activities, but the preservation of the concepts' relations in the CC should be considered in future work to help both students and teachers. At this point, the CC can be seen as a promising approach to foster *TISL* [CLJ11] and a good starting point to support students' reflection.

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