Monitoring Conceptual Development: Design Considerations of a Formative Feedback tool

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Monitoring Conceptual Development: Design Considerations of a Formative Feedback tool

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Abstract:

This paper presents the design considerations of a tool aiming at providing formative feedback. The tool uses Latent Semantic Analysis, to automatically generate reference models and provide learners a means to compare their conceptual development against these models. The design of the tool considers a theoretical background which combines research on expertise development, knowledge creation, and conceptual development assessment. The paper also illustrates how the tool will work using a problem and solution scenario, and presents initial validations results. Finally the paper draws conclusions and future work.

1 Introduction

In modern educational practice, lifelong learning is a mix of formal and informal opportunities, both of which emphasise development of independent self-directed learning. This is encapsulated by workplace learning environments where learning trajectories reflect interactions of learners with peers and professionals from their own domain, as well as with "clients" (e.g. patients, students, or customers). In such complex circumstances, it is sometimes difficult for learners and their tutors to discern clearly how a specific individual covers key topics and how they might apply this to "real life" issues. Hence, self-directed learning requires support, through formative feedback, but a key issue is how to gather and evaluate the evidence on which such feedback could be based.

Our work comprises the design and development of a formative feedback tool which monitors conceptual coverage of topics based on an automated analysis of textual evidence presented by learners, in comparison with others or over time, to identify shortcomings, misconceptions, and emerging learning opportunities. It uses textual artifacts from both individuals and groups of learners, such as essays or blogs, to establish a visual representation of how learners relate concepts to one another. These visual representations are automatically generated from text inputs using Latent Semantic Analysis [1], a Natural Language Processing technique that can identify the concepts and their relations between the concepts contained in input text materials.

Learners, therefore, are able to compare their own model with an emerging group reference model in order to identify differences, or to get feedback on where to seek advice from their tutor. This enables learners to monitor their development over time. Tutors can inspect the conceptual development of individuals and groups and use the outputs of the tool to inform their interactions with learners.

This article presents the design considerations of this tool, and illustrates the difficulties learners might have to understand their conceptual development describing a problem scenario, along side with a solution scenario which describes how the envisioned tool will support learners to understand their expertise development and tutors on have information

about how learners are developing their understanding. Finally, the paper presents initial validation results of the tool, and draws conclusions.

2 Design considerations

The central premise on the design of the tool is that learner's conceptual development is closely reflected in the textual utterances learners express as part of their evolving domain knowledge [2]. More precisely, the concepts used and the relations expressed by novices and experts change through time in a systematic, experience based fashion. While developing expertise, learners participate in a knowledge building cycle [3], which comprises cognitive and social processes. A cognitive process focuses on perception, memory and meaning; it assumes the memory is an active processor of information where knowledge plays an important role in learning. A social process assumes that learning is a social activity, which occurs in interaction with others. It takes into account both the learner and the environment, where learners are pro-active producers of the environment in which they operate.
Learners should understand, therefore, how they are developing their expertise not only from a cognitive point of view, but also from a social point of view. From a cognitive point of view, learners need information so they can compare their understanding of the topic against the intended learning outcomes. From a social point of view, they need cues so they can compare the differences in how they conceptualize a topic with respect to how others (e.g., peers, colleagues, members of a group, etc) do.
In this knowledge building cycle, learners are, therefore, developing their expertise taking part in cognitive and social processes. In these processes they (re-)elaborate, provide and receive feedback from others and from themselves. Their conceptual development needs to be identified. As experts and novices differ in the way they organize concepts and relate them, it is important to identify the process of measuring conceptual development. The structural approach proposed by [4] propose a structural approach to assess the individual's knowledge of a particular domain. The approach consist of analyzing how the learner organizes the concepts of such a domain. This approach involves three steps: knowledge elicitation, knowledge representation, and evaluation of an individual's knowledge representation.
Based on this theoretical background, the design of the envisioned tool is grounded on the idea that providing formative feedback should consider:

- Learners level of expertise is reflected in the way they link and relate concepts, in how they express they knowledge
- Learners develop their expertise in a knowledge building process, which encompasses cognitive and social perspectives; Learners build knowledge both personally and collaboratively.
- Learners conceptual development assessment requires to elicit, represent and evaluate learner's knowledge.

To this end, it is required that tool provides learners with diverse ways of comparing their understanding against different reference models, mainly [5]:

- Predefined reference model, considering indented learning outcomes described in, for instance, course material, tutor notes, curriculum, etc.
- Group reference model, considering the concepts and the relations a group of people (e.g., peers, participants, co-workers, etc.) used the most.
- Learner's model, considering the input texts of the learner (e.g., essays, articles, blogs, writing assessments).

Using the tool, learners could compare evidence of their knowledge, so-called "learner's model", (e.g. text inputs such as essays, blogs, "think alouds" etc.) with different reference

models, so they identify similarities and differences. Learners can submit new evidence of their knowledge and receive formative feedback as often as they want. Moreover, learners could monitor their own expertise development as the tool should provide also comparisons of the learner's knowledge evidences previously submitted.
To ensure educational value and applicability of the envisioned tool, we employed a scenario-based design methodology [6], an approach that combines structured design with early stakeholder involvement and use of natural language to foster common understanding between the different actors involved in the design, development, validation and employment of the service (stakeholders of the end product as well as interdisciplinary developers). Part of this methodology includes developing two types of scenarios:

- A Problem Scenario that describes the current situation for a specific institution. The main focus is on the real educational problems and their associated tasks. In this phase the pedagogical orientation of is introduced. Although this may limit the generic use of the scenario it is required to generate usable solutions. For instance, solutions that are valuable for Problem-Based Learning contexts often conflict with the demands for Tutor-controlled approaches.
- A Solution Scenario that describes the possible target situation based on the associated problem scenario and acts as a 'Business Case'. It is used to elicit feedback from the main stakeholders on the narratives (and interactions) of these scenarios.

In the rest of this section we elaborated, therefore, a problem and solution scenario [7]. The former illustrates the problem of monitoring one's expertise development, and the latter, which is illustrated with a working prototype of the service, depicts the functional design of the envisioned tool and how it will work.

2.1 Problem scenario

Marion is a learner in the Medical School of the European University. As in most medical schools in Europe, learning is underpinned by Problem Based Learning (PBL) activities, supported by opportunistic workplace experiences which in practice results on students following different routes through the curriculum. Marion, as her peers, will have a quite busy schedule this semester as she is expected to be moved from placement to placement in eight week cycles and combine them with structured formal learning activities, for example problem based cases regarding a specific subject that require also doing a lot of peer-group activities. She will also undertake much informal learning according to the situations and opportunities that arise in the workplace.
Dr. Moon is a tutor in the Medical School of the European University, where she teaches patient care subjects. She also gives clinical advice to students in the University Hospital, where she works as Paediatrician. She is very positive about the PBL methodology and its self-learning focus for Medical Education, but she also admits that is very work demanding and time consuming for learners (e.g., they have to be self-directive) as well as for tutors, particularly with large number of students as the University has provide formative feedback is a challenge.
The following problems are encountered:

- Learners receive formative feedback from Tutors on their learning at particular trigger points, for example at the end of a PBL case exercise (i.e, course dependent). However, feedback in between these trigger points is inconsistent in nature and timeliness, depending on the enthusiasm and time available of the individual Tutors.

- Learners have difficulties to understand the limits of their knowledge, as many feedback provided by tutors is provided in a group context rather than on individual basis.
- Learners should be aware of limitations of expertise and be able to address the issues this raises. This will help them to become independent life long learners, with a clear view of the limits of their expertise and competencies. Safety of patients depends on this.
- Tutors as well as placement supervisors might be giving feedback on similar activities, competences. This feedback may differ between tutors, making it hard for the student to interpret.
- Most feedback will be on products and not on processes, and therefore is limited (in quality and scope).
- Tutors give feedback to learners when it suits their own schedule, which makes the feedback opportunistic.
- Tutors do not provide feedback within a common framework.
- Tutors, for pragmatic reasons, often present their feedback (e.g., end of PBL case, end of project, etc) in a group context rather than on individual basis.

2.2 Solution scenario

This week Marion is working together with a group of peers on a problem based case about "cervical dysplasia". They have to collect related information, and discuss and agree on the diagnosis on the case. At the end of the activity, they have to present their results to their peers. Learners are also asked to keep a learning diary in the shape of a blog to reflect on their learning. The learning activity goes well, but Marion is not sure that she grasps all the notions and concepts of the topic, and if her understanding of the topic corresponds to the level she is supposed to have reached at this point in her learning career.

She then decides to use the conceptual development monitoring service, which is a freely available widget that can be included in her Personal Learning Environment. Marion finds the topic space "Oncology- 3rd year", created before by her tutor Dr. Moon. She then submits the blog entry she wrote about cervical cancer.

After processing Marion's blog entry, the service displays a topic representation graph that includes the concepts the blog entry contains and how these concepts are related. The graph uses colours to identify also different themes (i.e., clusters of concepts). Figure 1 shows an example of a representation graph. There Marion can see that in her blog entry she is relating, for instance, the concept of "Cancer" with "Prostate" and "Breast". But also that she relates the theme 'Cancer" to the theme "Research".

Marion can also compare her topic representation graph with other topic representation graphs. These representations can be, for instance, a group reference model (a graph that consists of all topic representations of her peers) or a predefined reference model, which represents the intended learning outcomes (a topic representation her tutor created using learning materials). For instance, Figure 2 shows the graph Marion sees when she compares her topic representation (in blue) with the tutor's intended outcomes of the case about "cervical dysplasia" she was studying with her peers (in green). There it becomes evident to her that in her blog she is not mentioning topics related to cancer, such as the "Care" aspect (showed in the left top corner of the graph) and the "Keeping up to date" aspect (shown as 'knowledge' in the middle of the graph).

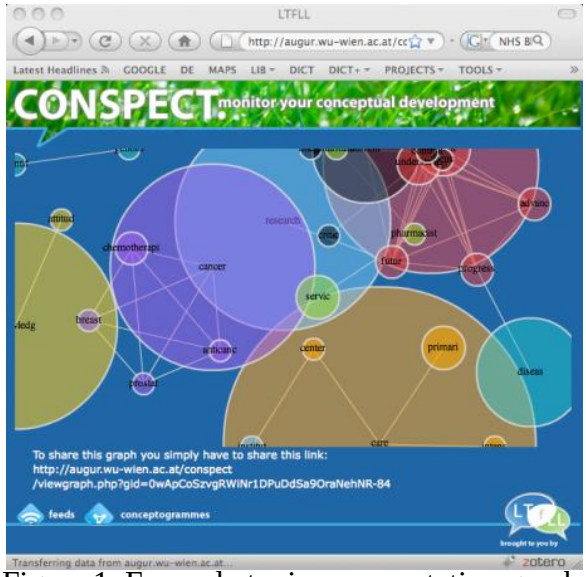

Figure 1. Example topic representation graph.

Figure 2. Example comparison topic representation vs. predefined reference model.

If Marion decides to ask Dr. Moon for feedback, she will make her topic representation public, so Dr. Moon can see it and provide feedback. If this is the case, Dr. Moon might explain to her that she should be more aware of the "Care" aspect, which includes "Diet", but also "Cancer pharmacology'. She recommends Marion to read a book chapter as well as two journal articles so Marion improves her understanding.
Marion can also use the service to compare her topic representation graph to that of any particular peer (of the peers that have also made their representations public). The service also keeps a record of Marion's topic representation graphs, so she can compare her representation graphs over time. This allows her to gain insight into her progress in understanding the topic.
Marion likes the tool, so she decides to introduce it in an informal learning context as well: the Latin American literature group she is part of. In this context she acts as tutor ("initiator") and creates a topic space for "magical realism". Her friends include the tool in their Personal Learning Environments, join the topic space Marion created, and use the service to submit their knowledge evidences. Some of them submit a blog entry, while others decide to submit an essay they wrote about the topic. They work with the service to get topic personal representation graphs of their understanding side by side with their friend's representation graphs of the topic. As the service can create a topic representation graph that is based on all

their joint submissions, they can, when they meet face-to-face, use that representation (the group reference model) to see and discuss their shared representation graph of the topic. They also have been using well-known literature about the topic to create a pre-defined reference model. This allows them to compare and discuss about the differences and similarities between the different models, namely their personal topic reference models, the group reference model, and the predefined reference model.

3 Initial validation

Currently, a first version of the tool has been developed and a verification study has been performed [8]. Moreover, a small-scale validation study has been conducted in the Manchester Medical School (UK) [9]. The validation evaluated different features and claims:

- The service allows tutors to easily identify, using the service's reference models (individual model, pre-defined reference model, peer-model), individual learners whose topic coverage has progressed more or less than their peers.
- The service allows tutors, using the service's reference models, to easily identify individual learners who are not developing in line with intended learning outcomes
- Tutors are able to monitor the progress of individual learners over time using the service's reference models.
- Tutors are able to monitor the progress of groups of learners over time using the service
- The service allows students to compare their personal reference models with those of other learners
- The service allows students to compare their own reference models with a pre-defined reference model that is representative of the learning outcomes.

Medical students and a tutor have been invited to participate in validation sessions in which they had to work with the current version of the service using a blog entry as input for the service. Participants reaction regarding the tool was positive: "*it's quite a cleaver way to compare yourself to what other people have written down, that you've covered everything you need to cover, which is a problem in PBL at the moment*". The tutor, however, pointed out that she may need to know more about how the service works before she can trust in the service.

Interesting, participants came up with new ideas on how the service could be of use. They suggested that as the service identifies the most important concepts of a text, these concepts be of use as starting point to write an essay. Also students pointed out the service might provide useful information for final examinations. As a memory aid of what they had learnt or had written in previous years. Finally, learners also mentioned that they would like to use the service to generate a conceptual map of text materials available on the web (Wikipedia, newspaper articles, etc.), so they can have a reference model useful for comparison and to spot the key points of the texts in question.

4 Conclusions and future work

This paper presented the theoretical considerations, design and requirements of a service that will provide formative feedback to learners, supporting them on understand their expertise development; the premise is that different reference models should be generated in a automatic way. The design of the service considers a theoretical background which combines research on expertise development, the knowledge creation cycle, and the process of assessing the individual's knowledge of a particular domain. To illustrate the difficulties learners might have to understand their conceptual development a scenario has been described, along side

with a solution scenario which describes how the envisioned service will support learners to understand their expertise development and tutors on have information about how learners are developing their understanding. The design considers that the service can be used in both formal and informal learning settings. Depending how the use of the service is implemented in the learning context, learners can assume both tutor and learner roles.
The validation has already provided feedback for an improved version of the service. This version will include particularly recommendation of learning resources, consider missing concepts, and edition of the topic representation graph. The new version will be validated further in a different context with stakeholders whose text inputs are in Dutch. In this way we plan to validate the service in at least two different contexts and two different languages.

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