Are you thinking what I'm thinking? Representing Metacognition with Question-based Dialogue

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Abstract. In the following paper, we present *Noracle*, a tool for creating representational artefacts of metacognitive thinking in a collaborative, social environment. The tool uses only question-asking, rather than the typical question/answer paradigm found in threaded discussions, as a mechanism for supporting awareness and reflection on metacognitive activity, and for supporting self-regulated learning. The web-like artefact produced by learner contributions is intended to support learners in mapping a given domain, identifying points of convergence and recognizing gaps in the knowledge representation. In this paper, the authors present the model of the tool, a use-case scenario and a discussion of the opportunities and limitations related to this approach.

Keywords: self-regulated learning, reflection, metacognition, learning analytics, inquiry, knowledge representation, technology-enhanced learning

1 Introduction

The basic metacognitive element of awareness and reflection is *self-observation*. Meaningful self-observation affords the opportunity for judgement and reaction, providing evidence of the impact of certain strategies, beliefs and attitudes toward one's learning [23]. It also requires strong inquiry skills, to ask basic questions like "*what should I observe and how do I best observe it?*" toward interpretative questions such as "*why is what I am observing happening and how do I control it?*" Self-observation seems deceptively easy. If not trained and supported, it can be too superficial or unstructured to give the individual much insight (*ibid*). In addition, though Self-Regulated Learning *requires* reflection on learning to learn, it is typically perceived as a more solitary activity occurring outside of the classroom [3].

To support learners in acquiring learning strategy knowledge, we believe it is necessary to provide tools that allow for 1) *social* integration of knowledge and experience about learning, 2) a *structured* space to explore and represent knowledge, as well as identify relevant knowledge gaps, and 3) opportunities for *reflection* and exchange on how best to address knowledge gaps. In this paper, we present a model of a social, structured space for both reflecting on metacognitive assumptions and representing metacognitive knowledge, using question-based dialogue. We illustrate the application of this model at these early stages using a tool called LiteMap [5], and discuss the possibilities and limitations involved.

Our model, which we refer to as *Noracle*, is primarily based on the *construction-integration* theory of knowledge acquisition. New knowledge is integrated into an individual's *conceptual map* through reflection, by anchoring it to existing information [17]. In the context of Technology-Enhanced Learning, we apply this model to collecting and integrating *strategy knowledge*, or *metacognition*, among a group of online learners to create a virtual, visual map of inquiries related to their metacognitive thinking. Through use of questions, rather than answers, we draw on the traditions of Problem-Based Learning (PBL) and Inquiry-Based Learning (IBL) to encourage deep-level reasoning and support the integration of both cognitive and metacognitive strategies in learning to learn [8][11]. Noracle is intended to build upon this tradition, triggering and exploiting human curiosity to support awareness and reflection. The shared visualization of inquiry that is born through collaboration in this space is the mechanism by which metacognitive thinking is explicitly *represented*, which might not only be "uniquely human", but also the building block of contextual knowledge construction [18].

2 Background and Related Work

Inquiry is the cornerstone of all learning. In the next paragraphs, we discuss how structuring inquiry in a social learning setting can contribute to helping learners become more aware of how they learn.

Constructivist theory suggests that learners can become more skilled at recognising certain opportunities and challenges to their learning over time, regulating their thoughts, emotions, behaviours and learning contexts appropriately [12][24]. These skills are collectively referred to as *Self-Regulated Learning* [15][23] and have become a central goal of contemporary education [19][20]. However, self-regulation is a *process* and learners require scaffolding to break through certain challenges. It is necessary to utilise the social environment of learning to support learners' self-regulation by exposing them to new perspectives, ideas and methods through their peers and tutors. In this way, we assert that all self-regulation in learning is mediated and influenced by what is called *Socially-Shared Regulated Learning* [10]. Social components help to *scaffold* the process of learning to self-regulate also by *representing and interrogating* knowledge within a group. Boud suggested that all learning originates from the curiosity and motivation of the learner [2]. Problem-Based Learning, Inquiry-Based Learning, and Collaborative Learning attempt to trigger this process by providing open, partial pictures of a problem and relying on students' collaboration and reasoning to engage students in mapping out the problem area [7][11][17].

Social Learning approaches necessitate *quality* learner participation. Research indicates that learners are generally unskilled in asking deep questions that result in high-order thinking processes, such as meaningful reflection [8][9]. Learners also appear to have difficulty in *distilling* answers and engaging in cognitive *monitoring* [1]. Developing strong skills in question-asking and problem-mapping are, therefore, important precursors to success in reflection on learning. Skills can be strengthened by association with more highly skilled peers or with a tutor through facilitated practice [4][8]. Spending a greater portion of time considering learning strategies and the various implications these strategies have for performance is already a part of both PBL and IBL [3][11]. However, similar to the acquisition of content knowledge, the representation of that knowledge is important. Learners need a way of structuring their *strategy knowledge*, as well as their *self-knowledge*, to be able to recognize and fill in gaps related to how they learn. Noracle is an opportunity to mobilize technology as both a tool to encourage and represent inquiry.

3 The Noracle Model

In this section we present the main entities of Noracle and discuss their role and interconnection. Figure 2 illustrates these entities, identified as Classes and Relationships. *Learner* is a class that is used to describe the ordinary participants of Noracle. Apart from a standard set of attributes used to identify them (i.e. username, email, password), learners are the main agents that interact in the Noracle Space through various actions, discussed below. A *Question* is the central Class of Noracle spaces. Fundamentally, a Question is defined as a free-text field, which is authored by a Learner. Moreover, a Question can be *linked* to other Questions so as to form the web of Questions described below. Once a Question is posed, linking it to other Questions is optional. A Question linked to another Question joins the space of the pre-specified Noracle Space whereas a Question that is not linked forms a new Space.

Learners can provide feedback on Questions through *Annotations* and *Ratings*. These two entities share the same goal, which is to provide a mechanism for assessing the usefulness and the quality of a Question. An *Annotation* is created using a free-text field and multiple Annotations by an arbitrary number of Learners can be attached on a Question. For using Noracle in the context of Socially-Shared Regulated Learning, Annotations can be derived from the research literature on Self-Regulated Learning to indicate whether or not a specific question relates to how the Learner is thinking, feeling, or behaving, or the context in which learning occurs [15]. An optional, single *Rating* is provided by each Learner following a Likert rating scale.

A *Moderator* is a special type of user who has the permission to make modifications on the content created in Noracle. The purpose of this user is to be able to supervise the formation of a Noracle Space and its contents and make sure it doesn’t deviate from the Noracle objectives and context.

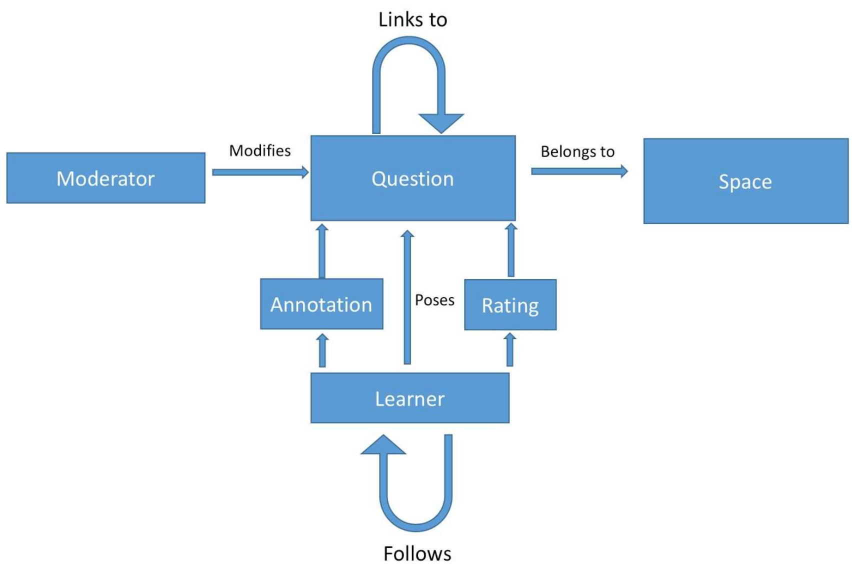

Figure 2: The Noracle Model

4 Applying Noracle for Metacognitive Representation

To illustrate the concept of Noracle without a functional prototype, we decided to appropriate a tool for structuring argumentation called LiteMap [5], in which we bound a small selection of 5 colleagues to deploy only the tools that are representative of the entities described in the model above to explore challenges in learning to learn. This included creating a user profile, raising an "Issue" as a Question, providing an Annotation in the comments, responding with Questions to the Questions of other Learners, using the "thumbs up/thumbs down" feature as a Rating and exploring the visualisations of social and issue networks as Space. For the moment, the directional arrows were ignored, except to illustrate that a connection between two Questions had been established (see Figure 3). The artefact created is public on LiteMap as "Noracle Test 1." While LiteMap is not a perfect representation, we conducted this exercise to highlight the basic components of the model and the underpinning pedagogical theories of Noracle.

Noracle intends to *train* question-asking by demanding that Learners engage only in question-based *dialogue* under supervision and facilitation (of a Moderator, for example). The starting *nodes* or Questions that Learners ask are triggered by their individual curiosity and then expounded upon through the addition of *follow-up* questions (submitted by any user) that help the original asker to expand or narrow their focus on a particular issue. As the nodes become linked, a web of Questions emerges that represents the metacognitive reflections of the individuals involved (see Figure 3). As the web expands, Learners and Moderators can gain insight into what the cohort does and does not understand about learning to learn, uncovering gaps in learner knowledge that can be actioned by an educator (possibly the Moderator).

Through the Rating feature, the Learner can begin to create their own *peer-learning* networks by following those users who have proposed the most highly-rated Questions. The Moderator can also review highly-rated questions with Learners as part of the classroom content, to improve the quality of their question-asking by distilling features of useful questions. Additionally, the Moderator can use this data to improve awareness for the *social learning dynamics* of the cohort.

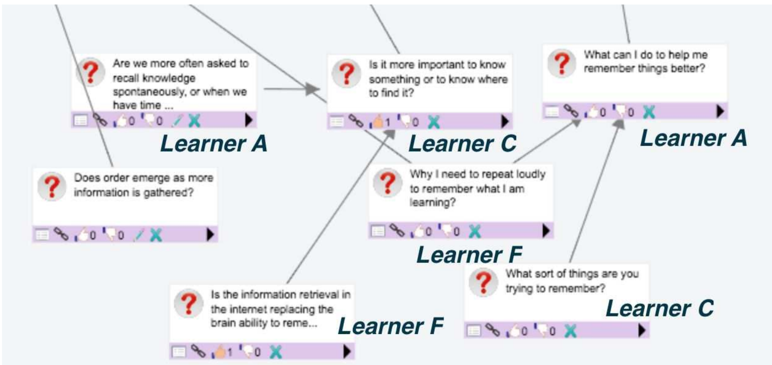

Figure 3: Question Web in Noracle

The Annotation feature gives Learners and Moderators additional information about what *type* of Question is being asked (whether it relates to thinking, feeling, behaving or context), to understand where specific challenges might lie. If a particular Learner consistently asks questions related to a particular area of self-regulation, for example, this gives Learners and Moderator an indication of the Learner's interests and which skills that Learner needs to build, to inform appropriate interventions.

The Annotation feature and visual representation also trigger reflection in other ways. Suthers discussed this phenomenon in terms of "*missing units*" triggering search [21]. Introduction of a *gap* (i.e. an Annotation field that prompts the user to think about what kind of question they are asking) encourages learners to consider how that gap can be filled. In fact, the existence of only Questions in the space has its own reflexive value in the absence of an Answer entity.

5 Discussion

Noracle as an information system is still at its early development stages and does not have robust evaluation results at this time. However, we can gain insights about its effectiveness from the research literature and anecdotal evidence from application of the model in the physical classroom, as well as the informal LiteMap trial. Noracle was developed in 2012 by Track2 Facilitation (http://www.track2facilitation.com/) as a face-to-face reflection method (similar to "speed-dating" with questions) in the context of non-formal learning. Participants have consistently described this method as being helpful to their process of deliberation and sense of self-esteem in course evaluations. Experiences with the method tended to confirm prior research findings that absence of answers leads to *self-discovery*, which is a more satisfying experience for learners [13]. With facilitation by a moderator, the effects of self-discovery on learning outcomes are even more pronounced [14].

The decision to digitise this tool emerged from the recognition that not all learners were able to organise and represent what they took away from the experience of Noracle. They had difficulty remembering who had given them a useful follow-up question in the group, for example, and it was difficult to create a *joint representation* of complex topics with the limitations of physical space. The "enhancement" that technology can offer this tool is exactly regarding *scale* and *analytics* [8]. The LiteMap trial indicated that Noracle can be used among an open group of anonymous, distributed learners, or a closed cohort of students, for example. It can create representational artefacts that are more considerable and complex than those that would likely be attempted in a physical classroom, and it can operate in both synchronous and asynchronous learning environments. Moreover, it can collect data on users, their contributions and their connections to one another over time.

Representational maps have been shown to resolve some of the issues of "coherence and convergence" found in typical classroom forums, and they promote the generation of hypotheses and collaborative activity [22]. This addresses, at least in part, the issue of *motivating* learners to ask questions, so that they can become skilled at other aspects of inquiry [9]. The analytics collected through Noracle can be used in real time and over time to deliver insights that impact both teaching and learning, especially in conjunction with a representational artefact. For example, research indicates that peer-learning in the context of a developmental construct, such as learning to learn, is more effective than individual study [6]. Being able to estimate the prior knowledge of a peer-learner has also been shown to produce more positive impacts learning outcomes [16].

However, Suthers [21] cautioned that representations have their own impacts on collaborative and individual inquiry. Surely the presence of this artefact limits the types of discussions that can be had about learning, simply because the tools that are there to help learners express themselves are limited. Not only do the elements described in the model limit what can be known from inside of Noracle, but Learners will additionally produce their own limitations, based on their own perceptions of the system.

6 Conclusion

Though strategy knowledge is as important as content knowledge in learning, learners (and teachers) tend to spend much more *social*, *structured* time on the perceived primary task of learning content knowledge and less on the perceived secondary task of reflection and learning to learn. As a result, many learners are much more aware of *what* they know than *why* they know it, which frustrates the *transfer* of learning skills from one domain to the next. By scaffolding inquiry in a tool such as Noracle, we believe that learners can both gain access to new ideas and perspectives on their learning strategies, and hone their skills in question asking, while contributing to the representational artefact of metacognitive knowledge created by the group. Over time, patterns emerge that we believe can provide the learner with insight and give them a foundation upon which to change or support their current approaches. In the future, we hope to fully implement this tool, accompanied with preparatory and debriefing activities that a Moderator can use to facilitate its use. We also intend to conduct a robust evaluation of the tool and its effects on learner motivation, metacognitive awareness and general learning outcomes.

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