Personalised knowledge representations: the missing half of online discussions

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Abstract
In this paper, we highlight a concern with using online discussion for learning. We argue that there is a lack of technological support for the development of personalised knowledge representation for most online discussion forums. Analyses of existing discussion forums suggest that there is a range of collective knowledge representation mechanisms which support a group or a community of learners. However, such mechanisms may not necessarily lead to learners’ internalisation of collective knowledge into personalised knowledge. We discuss how internalisation can be facilitated through the notion of knowledge objects, while externalisation can be mediated by idea artefacts. These notions are translated into technological supports and suggestions of how online discussions can be designed differently from the common threaded discussion.

Introduction
In this paper we suggest the need for the dyadic nature of knowledge representation in online discussions, which consists of both the collective and the personalised dimensions. We recognise that most current online discussion forums lack the facility to support personalised knowledge representation. As a result, participants are either overwhelmed by the vast volume of contributions (if they are motivated to participate) or do not have ownership of most of the discussed issues (and thus are de-motivated to continue participating). Such phenomena connote a lopsided focus on the collective nature of knowledge representations. We identify the missing personalised half of the dyad by discussing the distinction between “objective knowledge” and “subjective knowledge” (Popper, 1979). Objective knowledge is collective in nature whereas subjective knowledge is parallel to personalised understanding. We further analyse the dyadic relationship between the collective and personalised knowledge representations.
by discussing the notions of “knowledge objects” (Entwistle, 1995; Entwistle and Marton, 1994), “scientific intuitions” (Marton, Fensham and Chaiklin, 1994), and “idea artefacts” (Dewey, 1933; 1981). These notions, we conjecture, are the cognitive links that translate collective representations into personalised understanding and/or vice versa. Finally, we suggest a broader range of knowledge representations than the existing threaded ones in online discussions by introducing epistemological forms (Collins and Ferguson, 1993) which aid the support of both forms of knowledge representation.

Objective Knowledge versus Subjective Knowledge

The recent proliferation of student online discussions calls for a re-examination of the meaning of knowledge. Though not explicitly or intentionally so designed, most discussion forums seem to focus more on supporting the construction of collective knowledge rather than on the construction of personalised understanding. There seems to be an assumption that during the processes of social dialogue, students’ personal understanding is automatically guaranteed. For example, students could be engaged in discussing how different parts of the human body works. A collective representation of the negotiated knowledge surrounding the human body, and how it functions, could then be captured on a designated website. By examining the richness of such a collective representation of knowledge, one could mistakenly assume that all the students who have contributed to the collection have learned from it. In fact, different students contribute to different parts of the knowledge representation and this collective representation may not necessarily belong to any individual student. The situation could well be that individual students have developed personalised understanding differently and perhaps with misconceptions. In essence, how can we better facilitate the process of constructing personalised understanding in relation to collective understanding?

The above distinction between collective knowledge (understanding) and personalised knowledge (understanding) representations is concomitant with Popper’s notion of knowledge in the objective and subjective perspectives. In his book *Objective Knowledge: An Evolutionary Approach*, Popper (1979) proposed the existence of three worlds: the world of physical objects or of physical states (World 1), the world of states of consciousness or of mental states (World 2), and the world of objective contents of thought (World 3). Examples of World 3 objects include concepts like the square root of 2. Such a concept may not belong to anyone’s subjective state, although people may know what the square root of 2 is, but it is an immaterial objective object in World 3. According to Popper, the objective knowledge (in World 3) remains largely autonomous from the subjective knowledge (in World 2). Knowledge (of different states; either currently accepted, rejected, or to be verified) in World 3 is objectivistic and can exist without a knowing subject, whereas subjective interpretations (ie, subjective knowledge) of the objective knowledge exist in individuals’ minds (World 2). In other words, different individuals could and will interpret objective knowledge subjectively and differently. Amongst individuals, differing levels of understanding—arising from different perceptions and interpretations—are possible based on one’s comprehension of any World 3 object.
In the context of online discussions, collective knowledge representations are “stored” or archived and thereby can be referred to (in a similar metaphorical view with World 3 objects). The personalised (subjective) knowledge, on the other hand, is only meaningful to individuals, and may contain possible biases, misconceptions, and prejudices. What we are arguing for is a learning situation where personalised knowledge construction can be made more easily externalised and shared while the constructed collective knowledge can be made more easily internalised by individuals.

It may be useful to think of the analogy of the relationship between the library and one’s personalised knowledge. The library represents the current state of the negotiated knowledge of the (academic) community. However, it is neither owned by individual readers nor by those authors who wrote the books. It is a collection of all writings. Collectively, all of the authors form or construct the collective version of the represented knowledge. Even the authors do not own the collection, they have personalized versions of what they have written and acquired at any particular context in time.

In applying the library metaphor to an online discussion community, we do not and should not expect everyone to possess or read all the discussion. The learners read (portions of the discoursed and negotiated knowledge) only if they perceive it as relevant to their particular context at that moment in time. Therefore, we should provide a mechanism to facilitate everyone to build his/her own personalised knowledge representation and at the same time to keep a collective knowledge representation for open reference. The issue, then, is how to bridge the dialectic process between collective and personalised forms of knowledge representations so that the two forms of understanding inform each other.

Dialectical developmental processes of internalisation and externalisation
The notions of objective and subjective knowledge lead to our conjecture of a dialectical developmental process of internalisation and externalisation between these two worlds. The internalisation process would refer to how objective knowledge is interpreted and appropriated by individuals from the objective world to the individual subjective world. The externalisation process, on the other hand, describe how subjective inspirations or mental or psychological ideas are externalised and become objective knowledge. The notions of “knowledge object” (Entwistle and Marton, 1994) and “scientific intuition” (Marton, Fensham and Chaiklin, 1994) seem to provide a possible explanation of such transitions between the two worlds.

According to Entwistle and Marton (1994) and Entwistle (1995), during the internalisation of objective knowledge, individual students form knowledge objects differently. Knowledge objects have the following four characteristics: (a) the learner’s awareness of a tightly integrated body of knowledge, (b) the experience of visualisation and “quasi-sensory” (eg. a semi-visual image or representation of the integrated body of knowledge), (c) awareness of unfocused aspects of knowledge that once triggered the unfocused parts of the knowledge object are available for one’s exploitation, and (d) the structure or form of the knowledge object. Regardless of how students learn, the first
three characteristics of the constructed knowledge objects remain similar. The only difference between a more sophisticated student and a surface learner is the structure or form of the knowledge object. In addition, Entwistle and Marton suggest that the knowledge objects seem to be originally formed in the foreground of consciousness and later either integrated with or excluded from the individual’s existing schema (in the background). Since knowledge objects are formed before they are finally integrated with one’s subjective knowledge, they thus serve as a transitional state for the internalisation of objective knowledge to subjective understanding.

Entwistle and Marton (1994) tried to further compare knowledge objects with scientific intuitions. They found coincidentally that these two concepts share much in common. Scientific intuitions also have characteristics such as the sense of an object—likened to an entity with a sensory “flavour” (quasi-sensory) and the awareness of the unfocused aspect. We expand their notion of scientific intuitions to subjective inspirations or ideas artifacts. Dewey (1933) showed that ideas have the potential of arousing an alert mind, carrying students to new fields, branching out into new ideas as a plant sends forth new shoots. Ideas also help students to see meanings in a new light and with a new understanding.

During the process of discussion, many original ideas are generated and externalised by individuals. These ideas are subsequently negotiated, organised and situated to test for corroboration (Hung, Chen and Cheung, in press). The intersubjectivity reached within the community of learners is then formalised as objective knowledge. That is, ideas (or idea artefacts) are originally formed by individuals and then later externalised through negotiations as objective knowledge. The threads found in most discussion forums typify this externalisation process of how subjective ideas and intuitions contribute to the formation of objective knowledge which are gradually detached from the people who originated them and ultimately, in Popper’s term, do not have a knowing subject! One major concern is how these links between personalised and collective knowledge can be supported both cognitively and technologically.

In essence, we propose the necessity of technological supports for making overt the transitional knowledge (knowledge objects and idea artefacts) through the means of technological aids in online discussions. Epistemic structures (as adopted in the next section) are one suggestion where transitional forms of knowledge can be made overt. With knowledge objects and artefacts made clear (from collective to personalised forms and vice versa), students have a clearer basis for a constructive alignment of their personalised knowledge representations with the collective ones.

Figure 1 summarises the dialectical developmental processes between internalisation and externalisation.

Technology supporting knowledge representations
The distinction between personalised and collective knowledge representations questions the assumption that participants in the social dialogue will automatically
acquire the intersubjectivity reached within a particular community of learners. By only supporting the construction of the collective knowledge representation (using threads as the underpinning metaphor), we may unknowingly discourage or even impede students’ personal understanding because (a) such support does not foster/facilitate personalised understanding; (b) it provides limited opportunity for multiple foci in discussion and thus does not cater for the varying needs of individuals; and (c) the mass of contributions remains overwhelming. We argue for the necessity of technological supports for this transformation. In addition, we also challenge the adequacy of the traditional threaded discussion representations, which, we believe, are problematic in at least four areas: (a) difficulty in summarizing the current state of the discussion, (b) difficulty in referring (or linking) to a message posted earlier (thus, the need for an easy way to index and refer to messages), (c) difficulty in determining which thread to go to because a message could be related to more than one message, and (d) difficulty in tracking all messages and filtering only the relevant ones.

We propose that knowledge representations, though not the knowledge itself, can be transitional aids and supports to the dialectic internalisation and externalisation processes. For example, the threads of a discussion are visual representations that bring together all externalisations from participants. In other words, these visualisations facilitate and coordinate the organization of the collective knowledge representation. In a similar manner, the personalised knowledge representation would assist individuals to internalise the current state of the discussion, translate it into personalised knowledge objects, and later integrate it into their own existing schema.

It is then logical to think of two types of technological support. One for collective knowledge representation (for externalisation and negotiation) and the other for personalised representation (for internalisation). Because most research in the field focuses on the collective knowledge representation, we will briefly discuss how technology supports such a process including the externalisation and negotiation of intuitive inspirations and ideas. After which, we will describe in detail how technology supports personalised knowledge representation, and thus the internalisation towards personal understanding.

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Collective knowledge representation—support for externalisation and negotiation

Supports for externalisations are generally accomplished by the collective knowledge representations. For example, the collaborative learning application Knowledge Forum helps provide learners with a scaffold to make sound arguments by hinting “sentence starters” (eg, my theory is..., or I agree that...) or providing argumentation structures (Scardamalia and Bereiter, 1999, see Figure 2 for Knowledge Forum).

Figure 2: Knowledge building in Knowledge Forum

QuestMap allows learners to use different icons (which can only be linked in a certain manner) to present their argument and to react to existing notes. For instance, an icon of “!” is used to represent ideas, “+” represent strength of the idea; “−” represents weaknesses, and a notebook icon represent evidence. So a person can start off by presenting an idea “!”, then someone reacts to it by using other icons or to question it with a “?” icon (Tan, 2000). The above two systems both try to facilitate the generation of ideas for externalisation and negotiation. Basically, there are quite a few of these collaborative online discussion forums advocating the social constructive approach, but these learning environments, as mentioned earlier, do not generally support personalised knowledge representations.

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Personalised knowledge representation—support for internalisation

An additional way of representing the knowledge in a personalised manner is needed. This representation is mainly to provide support for internalisation of the current state of discussion or knowledge.

We argue that a wider range of alternative representations is needed. As discussed above, threads are most commonly used, but are very limited. Efforts have been made to reduce problems delimited by threads. For example, Knowledge Forum (Scardamalia and Bereiter, 1999) uses a concept map-like graphical representation of the discussion threads. However, this representation is still fundamentally based on the threaded structure. There is a need to provide more choices. Collins and Ferguson (1993) analysed different knowledge structures and identified 16 different forms of knowledge representation, among which are list, tree, table, primitive-elements, etc. These epistemic structures as proposed could be used to frame how alternative technological supports (other than threads) can be designed to facilitate internalisation and the construction of personalised (or subjective) knowledge. As discussed above, students with different conceptions of learning construct knowledge objects with different forms and structures (Entwistle and Marton, 1994). A wider range of alternative representations would cater to the needs of the different students. In fact, it could well be that a student needs more than one form of structure for their personalised knowledge representations. For example, one subset of the representation could be in the form of a tree structure, while other parts could be that of a table.

In the following sections, we make some suggestions about how personalised knowledge representations can be supported and how epistemic structures and forms can be infused into online discussions. One possible scenario of technological support for personalised knowledge representation is that students are informed of an incoming new contribution each time another student posts a message. After reading a contribution there are at least four actions that a student may take: delete (ignore) the message (and therefore any subsequent ones in response to that particular message), archive the message by including the message in his/her personalised knowledge representation, respond to the message, and post a new message. These actions will have a bearing on the formation of the students’ personalised interpretation of the knowledge. We suggest a possible supporting mechanism below.

1. When a student ignores (deletes) a message, it implies that any subsequent messages in response to that particular message will not be visible to the student. Any ignored message will become relevant and visible again only if someone else makes a link from a message (which is in the student’s personalised knowledge representation; see point 2 below) to an ignored message. The student will then again be given a choice (prompted by the system) of whether to follow through that thread of discussion or to continue ignoring it.

2. When a student chooses to archive a message, he/she will have to decide how it is to be done. The student will have to construct a personalised knowledge representation (eg, any choice of epistemic forms; see Collins and Ferguson, 1993)
and decide where the message goes. The message could be linked to multiple messages or multiple nodes. Every link will have the potential to affect other students’ personalised knowledge representations because all students will be informed of this link (e.g., if the link activates one of the ignored messages). Students will construct their personalised knowledge representations differently from one another.

3. When a student responds to a message, the reply and the original message will be automatically added to the knowledge representation. There will be a link between the two messages. It is then up to the student to decide how the two messages are incorporated into his/her existing personalised knowledge representation.

4. When a student posts a new message (without responding to any messages), the message will automatically be added to the student’s personalised knowledge representation. In addition, all other students will be notified of this new incoming message. A new message will only show up in the collective knowledge representation, but not in the personalised ones. It is included in the personalised ones only when a particular student chooses to do so.

5. The significance or relevance of a message could be recognised by students and thus the human moderator is relieved from managing and is therefore able to focus on facilitating the discussions. Some “opinionator” online sites (which thrive on people asking for opinions and those who provide answers) heavily rely on rating and point mechanisms to motivate participation. These mechanisms may not work in the formal education context. One modification to the point system is to use “implicit” points. For example, when a message is referred to (e.g., some individual students choose to include that message into their personalised knowledge representation), a certain number of implicit points are assigned to that particular message. The larger the number of students referring to a message, the more “significant” is the message. The system could then have a “hall of fame” for most frequently referred to messages. The idea is to draw students’ attention to the most relevant contributions.

6. In organising the contributions for personal understanding, students could create categories (or nodes if it is a concept map structure) to help them visualise the knowledge. These organiser aids are personal and will only show up in the personalised knowledge representation. Messages from the discussion can then be linked or hidden under those categories for future exploitation. This mechanism is to support the “awareness of the unfocused” feature of knowledge objects.

A simulated example
We use a simulated example (Figure 3) to illustrate how the above mechanism works. We show step-by-step how the collective knowledge and the personalised representations evolve over time. Suppose there are three students A, B and C participating in the discussion.
**Step 1:** Student A posts Message 1. Student B decides to ignore it. Student C replies to Message 1 with Message 2.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Step 2:** Student A archives Message 2. Student B posts Message 3. Note that Student B does not see Message 2 because he/she chooses to ignore Message 1.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Step 3:** Student A archives Message 3 and links it to Message 2. Student C ignores Message 3.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9.png" alt="Diagram" /></td>
<td><img src="image10.png" alt="Diagram" /></td>
<td><img src="image11.png" alt="Diagram" /></td>
<td><img src="image12.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

*Figure 3: A simulated example*
**Step 4:** Student B is alerted by the system that Messages 1 and 2 might be relevant to Message 3. Student B decides to archive Message 2 and continues to ignore Message 1.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph 1" /></td>
<td><img src="image2" alt="Graph 2" /></td>
<td><img src="image3" alt="Graph 3" /></td>
<td><img src="image4" alt="Graph 4" /></td>
</tr>
</tbody>
</table>

**Step 5:** Student A replies to Message 2 with Message 4 and to Message 3 with Message 5.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Graph 5" /></td>
<td><img src="image6" alt="Graph 6" /></td>
<td><img src="image7" alt="Graph 7" /></td>
<td><img src="image8" alt="Graph 8" /></td>
</tr>
</tbody>
</table>

**Step 6:** Student B archives Messages 4 and 5 and links both directly to Message 3.

<table>
<thead>
<tr>
<th>Collective Representation</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9" alt="Graph 9" /></td>
<td><img src="image10" alt="Graph 10" /></td>
<td><img src="image11" alt="Graph 11" /></td>
<td><img src="image12" alt="Graph 12" /></td>
</tr>
</tbody>
</table>

*Figure 3: A simulated example (continued)*
Discussion and conclusion

As can be seen, once the number of messages grows, students will develop their personalised knowledge representations which are qualitatively different from one another. We can clearly observe, from the simulated example, how individual students personalise their understanding of the discussions based on decisions they make on how messages are processed. We can also see how the system provide hints to individuals to pay attention to unseen messages. These hints serve to support internalisation of the collective knowledge to personalised representation. Conversely, individual contributions (eg, idea artefacts) also affect how the collective representation looks. That is, individual externalisations are cumulated as collective knowledge. No one can dominate the process and every contribution counts.

In an ideal online discussion environment, students would have access to both collective and personalised representations. They could even superimpose the two to perform further compare and contrast. It is also possible to design the system in such a way that if a learner wishes, he/she could publish annotated remarks on why certain messages are included or excluded and why certain links are made the way they are.

In this paper we have highlighted a concern that most current online discussion systems only support collective knowledge representations, which primarily facilitates the externalisation and negotiation of intuitive inspirations or ideas. We have argued for the need to support personalised knowledge representations in order to cater for individual differences. Personalised knowledge representations are the transitional states of knowledge and understanding in the process of internalisation from objective knowledge to subjective knowledge. When translated to technological supports, the objective knowledge could be represented by the collective knowledge representation of an online discussion forum; the knowledge objects could be illustrated by personalised

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3}
\caption{A simulated example (continued)}
\end{figure}
knowledge representations; and idea artefacts could be the messages, which every individual learner contributes. Without these supporting mechanisms, students may soon be overwhelmed by the massive number of messages or de-motivated to participate due to inflexibility in choosing the more relevant topics to pursue.

It is clear that more research studies are needed to test the arguments and approaches proposed in this paper, in particular of the internalisation process. But, we believe we have suggested an attractive alternative to current states of online discussions.

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