Promoting Cognitive Processes of Knowledge Integration

Shitanshu Mishra and Sridhar Iyer
shitanshu@iitb.ac.in, sri@iitb.ac.in
Indian Institute of Technology Bombay

Abstract: Knowledge integration (KI) is an important ability by which learners relate the ideas from prior knowledge and new knowledge to come up with a well connected and coherent understanding of a topic. We present a qualitative investigation done around a student-question-posing (QP) based learning strategy which aims at improving learners' KI in data structures (CS2) course. The results throw light on how QP activity using questioning prompts support the improvement of the cognitive processes of KI in learners.

Introduction

Knowledge Integration (KI) is defined as "the process by which learners sort out connections between new and existing ideas to reach more normative and coherent understanding of science" (Lee, Hofstetter, & Linn, 2008). The cognitive processes of KI involve connecting knowledge pieces coming from the plethora of knowledge-base, built using prior knowledge and new knowledge. Better KI means richer connections among knowledge components, coming from new knowledge and/or prior knowledge, which ultimately leads to more organized and deeper understanding of a topic. According to the KI instructional patterns, a KI environment should support four processes (Linn & Eylon, 2011): (1) eliciting ideas from prior knowledge; (2) focus on new ideas to help distinguish or link ideas; (3) distinguish ideas; and (4) sort out ideas. These processes can be supported at the learning environment level. A huge repertoire of work has been done to accomplish this for science education (Chiu & Linn, 2011). In our research, we examine if these processes can be supported directly at the cognitive level using the cognitive tool of question posing (QP). This research work extends previous research (Mishra & Iyer, 2015) that gave a proof of concept that QP involves the KI processes at the cognitive level, and identified different strategies by which learners integrate prior knowledge and the new knowledge to come up with questions that can help them to explore related knowledge, within CS2 domain. The strategies are known as exploratory question posing (EQP) strategies. In this paper, we present a QP-based learning strategy that aims at improving learners' KI performance in data structures. Our learning strategy is a computer-based adaptation of the guided cooperative questioning (King & Rosenshine, 1993) which used generic question prompts. Instead of using generic question prompts, our learning strategy uses the EQP strategies (Mishra & Iyer, 2015) as the domain-specific question prompts. We call our learning strategy as 'IKnowIT-pedagogy,' where 'IKnowIT' refers to "Inquiry-based Knowledge Integration Training."

IKnowIT-pedagogy

IKnowIT-pedagogy consists of six phases of activities as follows: **(1) Phase 1:** Learner reads introductory information about EQP and its importance. **(2) Phase 2:** Learner watches a video lecture on a topic and does QP. In our implementation, the video *("introduction to the tree data structure")* was approximately 15 minutes long, and learner gets total 45 minutes for watching the video and pose questions around its content. **(3) Phase 3:** Learner reads detailed information about the three EQP strategies (Mishra & Iyer, 2015). These three EQP strategies ('Apply,' 'Operate,' and 'Associate') are used as questioning prompts for data structures. The details are as follows. i) Apply (or Employ), where learner integrates the concepts from given knowledge with some goal 'application' or 'structural arrangement.' ii) Operate, where the QP involves integrating given knowledge with known goal state (or modifications) and seek operations/procedure to achieve the goal state. iii) Associate, where concepts from given and prior knowledge are integrated to seek insight into the given knowledge or prior knowledge. **(4) Phase 4:** Learner analyzes the questions generated in step 2 and categorizes them into the three EQP strategies. **(5) Phase 5:** Learner criticizes the questions and their categorizations generated by another learner (pre-stored). **(6) Phase 6:** Learner answers reflection questions to reflect on her/his experiences in the previous five phases.

Study methodology and results

Participants in the study were the 31 first-year engineering undergraduate learners, out of which 12 participated in the focused group interview (FGI). During the study, the learners undergone an IKnowIT session, followed by the FGI. The broad focus of the interview was to investigate the effects of each pedagogical features of IKnowIT on learners' improvement of KI processes. Later, the interview was transcribed and analyzed with the theoretical lenses of exploratory question posing and knowledge integration framework (Linn & Eylon, 2011). Our process was based on the approach outlined by Charmaz (2006) that involves initial coding and focused coding. At the end of the analysis, the focused codes were abstracted into tentative theory (story) that is then checked against other parts of the data to test its explanatory power. The results include two stories coming out of the interview analysis. These stories explain certain mechanisms related to how exploratory QP and KI are linked with each other, and what are the effects of exposing learners to the three broad EQP prompts.

Story 1 – Linking QP and KI: Learners perceived that EQP is highly intertwined with knowledge integration. On the one hand, they perceived that more KI happens after they pose more questions - *"better question leads to better understanding… Questions drive the KI process, as questioning lead to getting more ideas."* Learners reported that QP required them to think more into the given knowledge, their relationship with what they already know, to focus on inconsistencies and gaps in their understanding, to focus on alternatives to what was given in the video lecture, and to elicit expectation mismatch concerning their prior knowledge. This was an important finding, as it shows that the effects of the learning activities clearly appear to support the first three out of the four cognitive processes associated with KI, as described by Linn and Eylon (2011): (i) Eliciting prior knowledge, (ii) Refocusing on given knowledge and (iii) distinguishing ideas. On the other hand, learners also perceived that better KI leads to better exploratory questions. They reported to have recalled their prior knowledge and connected them to the ideas given in the video lecture. These connections were in several dimensions such as comparing, contrasting, finding applications, finding methods of implementing ideas, etc. Learners perceived that integrating knowledge pieces is a precursor to the coming up with questions.

Story 2 – Role of EQP Prompts: Though the IKnowIT-pedagogy activities were primarily based on EQP and exposing learners to different EQP strategies (Mishra & Iyer, 2015), they perceived that the activities were more about understanding the topic in a better way than just being a QP session. We used the EQP strategies identified in the CS2 domain as questioning prompts. From the interview analysis, it was found that the utility of the EQP prompts was not just limited to assisting learners in posing better questions. Learners used the EQP prompts at several instances, viz.: (1) Before posing a question, or (2) After posing a question, or (3) Both before and after posing a question. Learners who used the strategies "before" posing question did so to either to give direction to their knowledge exploration or to make an explicit attempt to create a question that can demonstrate the structure of any EQP strategy. Whereas, the learners who used the strategies "after" posing the question did so with an intention to either validate if their question matches to the standard EQP strategies or to categorize their question and then determine the direction in which they should look for the answer. In the first case, learners reflected on the availability of relevant knowledge pieces and their possible integrations to suit the requirements of any strategy. In the latter case, learners reflected about the nature of their questions, i.e., which of the three EQP strategies a question matches with. Learners reported several other utilities of the EQP strategies such as: (i) it helped them in validating their questions *("makes us to know which is the best way to ask question.")*, (ii) improved clarity of questions *("knowing categories avoids the confusions due to overlapping multiple doubts, it gives direction")*. In this way, the EQP strategies also seem to help the fourth KI process of sorting out ideas by providing clear objective to the sorting process.

In conclusion, Story 1 shows the role of EQP activity in the IKnowIT-pedagogy. It shows that integrating knowledge pieces is needed for coming up with better questions. On the other hand, it also shows that posing better questions helps in refining and strengthening prior connections and provides objectives to further knowledge explorations and therefore leads to further KI. Story 2 throws light on the roles of EQP strategies in the IKnowIT-pedagogy. In the conference, we would present the IKnowIT-pedagogy and associated evaluations in detail.

References

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