# Digital Repositories to Support Teachers Extend their Teaching of Mathematics Problem Solving Heuristics

*HO Kai Fai*
kfho@nie.edu.sg

*Muthukumar S.L.*
kumarl@nie.edu.sg

*John HEDBERG*
jhedberg@nie.edu.sg

Centre for Research in Pedagogy and Practice
National Institute of Education, Nanyang Technological University
SINGAPORE

**Abstract:** To support participant teachers extend their teaching of mathematics problem solving heuristics, we explore the use of a digital repository which comprises a video component, a discussion forum and a databank of classroom resource. The video component consists of extracts from teachers' classroom practices and workshops which they had attended. The discussion forum is set up partly based on the video extracts and partly on issues raised by the participants. The databank of classroom resources comprises mainly 'classroom-ready' mathematical problems. This article looks at some considerations that went into the design of the repository, and concludes with a discussion on related issues of building up and continuing the repository.

## Background

Computer-supported collaborative learning (CSCL) environments have become popular in helping to support communities of learning by transcending perennial educational barriers such as time, geographical distance and the need to have common interests and goals (Stahl, Sumner & Owen, 1995). With advances in technology and its contribution to the educational landscape, traditional classroom learning interactive environments have become supplemented though not supplanted by various online modes of learning. Such e-learning platforms afford learning opportunities by helping to overcome constraints posed by the hectic schedules of both teachers and students in being able to get together and spend desired blocks of time in collaborative learning activities.

Clark and Mayer (2003) define collaboration as a structured exchange between two or more participants designed to enhance achievement and learning objectives. The array of technological tools has facilitated alternative electronic modes of collaboration besides the traditional ways of physical interaction and to augment the learning options for these participants. Learning is a social activity which is anchored in a shared context and is co-constructed collaboratively over time. Stahl, Sumner and Repenning (1995) assert that for such collaborative learning to succeed in the classroom, collaborative learning activities for students must be integrated with collaborative curriculum development resources for teachers. Such collaborative ventures between teachers can be conducted electronically by technological scaffolds in the form of chats, message boards, online conferences and e-mail (Clark & Meyer, 2003).

Many studies in the area of collaborative learning have fundamentally focused on student-centered collaborative learning environments to improve educational processes and outcomes. The

teachers generally play a peripheral role of being either gate-keeper or moderator. There has been dearth of literature on electronic learning environments that focus on teacher collaboration and their professional development. In fact Riel (1992) observes that research projects have often been unable to transfer the successful results of their study to other schools since they failed to take into account teacher-researcher and teacher-teacher collaboration. The very same technological scaffolds of discussion boards, chats and resource sharing platforms that have been used widespread in e-learning environments to support collaborative learning amongst students, could be harnessed productively to guide the cognitive and pedagogical professional development amongst teachers as well.

Pawan, Paulus, Yalkin and Fen-Chang (2003) assert that collaborative interactions are an essential element of pedagogy which has as its underpinning principle Bandura's (1971) "social learning theory" where common understanding arises through modeling, participation in and reaction to the behaviours and thoughts of others. Teaching and learning co-exist and need to be harmoniously balanced to bring out the best in an individual. Accordingly, besides routine teaching responsibilities, there should be a rich context for teachers to interact amongst themselves, and engage in metacognitive dialectics to reflect on their teaching practices and strategies to improve their own learning and teaching. Further, Clark and Mayer (2003) claim that such collaborative tools serve a knowledge management function by encouraging participants to exchange their own experiences thus broadening and their understanding of pertinent issues.

In this exploratory study we investigate how digital repositories can help facilitate the sharing and development of good pedagogical practices. We will discuss the design of a collaborative environment mediated by technological tools that can help teachers and educators to interact online, discuss issues of mutual concern and share not only teaching materials but their teaching strategies as well. We will explore how the repository might form the starting basis for building up a useful knowledge base that teachers can draw on to improve their classroom practices.

Overall the design of repository was guided by what Garet, et al (2001) identified as one of the core features of professional development activities that have significant, positive effects on teachers' increases in knowledge and skills and changes in classroom practices, namely opportunities for active learning. Through the repository we hope to create "opportunities for teachers to become actively engaged in the meaningful analysis of teaching and learning …". To this end we went about building a skeleton for the digital repository. The context comes from a strand of a larger study on developing heuristics for mathematical problem solving.

## The Conceptual Framework for the Repository

The digital repository is primarily based on a conceptual framework that allows Mathematics teachers to share ideas, methodologies and resources on Mathematics problem solving electronically, without expending unnecessary physical efforts and labour in physically meeting for these activities. This repository also serves as a platform to facilitate teachers discussion of effective teaching strategies and techniques to scaffold students' learning of problem solving skills, thus providing an arena for teachers to share what Hiebert, Gallimore & Stigler (2002) termed as *practitioners' knowledge.* Thus the repository becomes a *shared* workspace with asynchronous collaboration capabilities.

Based on the above considerations, the digital repository was designed to support teacher participants to:

- view extracted video clips of workshop(s) they had attended, and of classroom teaching sessions of both themselves as well as their participating colleagues.
- share resources that can be downloaded by fellow participants and be adapted to the learning needs of their students
- raise and discuss issues related to the workshop(s) they attended and their pedagogical practices, in particular what they could review within the repository.

The digital repository, as currently designed, should not be viewed by the teachers as the solution to solving their teaching needs by providing standard resources that could be downloaded and used instantly in the classroom. No teaching materials are sufficiently generic to be able to fulfill differing requirements of all students. Students differ in their cognitive abilities being bounded by diverse cultural, intellectual and psychological backgrounds. Acknowledging this fact, we had instead built-in mechanisms in the repository design that allowed teacher participants to manage the resources effectively to suit to the divergent needs of their students and to submit variations and version of resources. In accordance with the framework explicated by Stahl, Sumner and Repenning (1995) the repository scaffolds the four activities of locating, using, adapting and sharing resources. All the resources were arranged categorically in folders and sub-folders to facilitate searching for the distributed curriculum materials. These materials were stored in standard file formats such as text, pictures, video clips and spreadsheets to enable teachers to easily download them and use them. Adapting teaching resources to fit specific curriculum needs of the students in their classrooms is an important skill-set that needs to be possessed by competent teachers.

The design of the digital repository allowed teachers to extract out lesson plans and other question banks and add in or rearrange the content and use it in a variety of classroom activities such as group readings, collaborative research topic analysis and class presentations. The teachers could then channel back these modified resources into the repository for them to be recycled and used by other teachers involved in the pilot project. Finally the whole structure of the repository was framed on the underlying principle of mutually supportive sharing with the common purpose of improving teaching strategies in Mathematical problem solving heuristics.

## Video Postings and Discussion Forum to foster collaboration

Interactive technologies such as discussion forums enhance the learning process by providing a history of ideas as they are considered by the participants (Christopher, Thomas and Tallent-Runnels, 2004). Durham (1990) found that online discussions allowed an exchange of ideas and increased sensitivity to others' comments. This environment allows educators to "interact, collaborate, exchange ideas and engage ideas and engage in dialogue"(Gorski, Heidlebach, Howe, Jackson & Tell, 2000). In line with these arguments, a discussion forum was embedded in the collaborative learning environment to foster social interaction that would otherwise not be possible face-to-face as the participating teachers gave from geographically separate schools.

Kanuka and Anderson (1998) caution that productive collaboration and learning can only ensue if proper structures, motivation and applications are put in place to ensure increased understanding of this communication medium. The teaching and learning of mathematical problem solving provides a suitable platform for the repository, since collaboration needs to be anchored in contexts to simulate real-life issues with which the participant can identify and immerse themselves. In short the theme of online discussion has to be situated to focus the negotiation of meaning-making constructively.

During our online discussions, teachers were encouraged to share their insights on what pedagogic approaches and strategies they would adopt in attempting to teach students the necessary problem-solving skills. The adroitness in teaching these skills has already been affected by the teachers analytically reviewing strategies of other colleagues. Techniques and ideas which teachers may not be otherwise aware have surfaced during these discussions, these are currently being tried in other participant classrooms.

Besides flat and static discussion themes around which normally online interactive forums revolve, a novel way to solicit sustained communications online between the teachers has been attempted. Two types of video clips have been uploaded to the repository based on the following premises. Many teachers attend workshops with a view to *improve* teaching strategies and pick up tips they can use in their own teaching of problem solving. Often they learn constructive pointers but for a range of reasons are not able to employ them in their own classes. One possible reason for this is the lack of support in terms of organizing such pointers into a coherent network where they are easily retrieved. Through the provision of support — posting clips of the workshop which was conducted within the context of a larger study looking into teachers' teaching of mathematical problem solving. One example of a clip gleaned from a 3-hour workshop was about using Polya's four stages of problem solving to ensure that they explicitly taught alternative strategies. We thought such clips would be useful in that they are short, usually two to four minutes, and sufficiently compact to help generate ideas that are more easily adaptable to classroom use. In another example, a clip that focused on an extensible *non-routine* problem that was used in the workshop, one teacher reviewed the clip to adapt and reuse the problem in her class. By including such clips in the repository we hope to organize them into a coherent structure that mirrors the related curriculum.

Additionally, extracts of transcripts of the workshop where the teachers raised pertinent issues along with some clips were included as unfinished discussions. Insights shared are not always remembered, or recalled in a 'just-in-time' manner, the choice of unresolved issues was specifically chosen as a spark to create ongoing discussion, further exploration and experimentation. Leading to a more in depth analysis and improved understanding, and helping the particpants recall shared experiences and insights.

One of the participant teachers raised the following question:

> AP: How do you get students interested in reading the problem… because some of the students when they look at problem sums, they'd say I don't like … To them Maths is so troublesome… and that is it. But it would not be of a trouble if they take the time to just to read it.
>
> SK (Workshop leader): How do the others deal with this problem … to make the students read?
>
> …

Here there was a pause, and one other participant PT contributed:

> PT: I would read the question, I'd highlight that it is important they read and understand the question before they can even do it. And I'd read it again, and I read it the way I want them to read, and I pause at where or when something appearing where they can work on I'd pause there, and it'd help them solve that way.
>
> KF: (researcher): … and you taught your students to highlight the key words … We saw that when we were recording your students' pair problem solving episode, that they were like

highlighting key words ("gestures"). It was clear evidence that they listen to you … they model after you…

The other type of video clips is about the teachers' classroom teaching sessions. Here salient features of the video recorded lessons are posted. In addition to providing opportunities for viewing how other colleagues facilitate students learning problem solving skills and helping teachers broaden their range of classroom practices, the clips also serve as focal points for deeper analysis for *better* practices and critiquing for reflection. To encourage useful discussions, postings in the forum were configured to remain anonymous so that participants will not feel discomfort in critiquing the pedagogical practices of fellow participants. Considering the socio-cultural sensitivities, this we hope would help create a more responsive and engaging electronic environment of dialogue and reciprocity.

## Other Resources for the Repository

The other resources that are currently being explored for inclusion into the repository are the various types of problems that teachers can adapt and use in their classroom. In the course of our interactions and classroom observations, many teachers stuck to familiar end-of-the-chapter type of *routine* problems that rarely challenge their students to *problem solve*. We also found time constraints on teachers thus a shared enterprise to build up a databank of questions that is easy to store, retrieve, modify and use could more easily share the tasks of creating a set of relevant resources that include more challenging and non textbook types of problems.

## Building up and Continuing the Repository

At this time, the initial steps in building the repository have been taken. More clips of subsequent workshops/seminars covering other aspects of teaching and learning of mathematical problem solving will be added to extend the range of the repository. New video clips of teaching sessions, highlighting salient points as well as changes in classroom practices over time are currently being collected to be later shared and uploaded to further enhance opportunities for in-depth study, interaction and reflection for all the project members. We are also considering other types of videos that can be added. Video clips of pairs of students solving problems have been collected, adding them to the repository should help teachers gain some insight into the learning processes, problems and misconceptions their students go through when solving problems. Other possibilities including teachers' sharing of craft knowledge and experiences, are being considered.

Overall, the viability of the repository depends on:

(a) the degree its features supports teacher active learning and collaboration,
(b) the extent that its contents focused on improving and deepening of teachers' learning and teaching of mathematical problem solving,
(c) the participants' level of contribution, and
(d) technical aspects in terms of ease of accessibility and user-friendliness.

The repository will require at least one year of sustained effort to extend the current basic structure and resources, and to generate more contributions from the participating teachers. The

approach will be examined for its ability not only to create shared resources but to develop a community of practitioners focused on Mathematical problem solving and devising its own self-directed professional development strategies.

**References**


Bandura, A. (1971). *Social Learning Theory*. New York: General Learning Press.

Clark, R. C., & Mayer, R. E. (2003). *e-Learning and the Science of Instruction*. San Francisco: Pfeiffer.

Durham, M. (1990). Computer conferencing: Students' rhetorical stance and the demands of academic discourse. *Journal of Computer Assisted Learning*, *6*, 265-272.

Garet, M.S., Porter, A.C., Desimone, L., Birman, B.F., and Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), pp. 915-945.

Gorski, P., Heidlebach, R., Howe, B., Jackson, M., & Tell, S. (2000). Forging communities for educational change with e-mail discussion groups. *Multicultural perspectives*, *2*(4), 37-42.

Hiebert, J., Gallimore, R. & Stigler, J.W. (2002). A knowledge base for the teaching profession: what would it look like and how can we get one? *Educational Researcher*, *3*(5), 3-15.

Kanuka, H., & Anderson, T. (1998). Online social interchange, discord and knowledge construction. *Journal of Distance Education*, *13*(1), 57-74.

Mary, M. C., Julie, A. T., & Tallent-Runnels, M. K. (2004). Raising the bar: Encouraging high level thinking in online discussion forums. *Roeper Review*, *26*(3), 166-171.

Pawan, F., Paulus, T. M., Yalcin, S., & Chang, C.-F. (2003). Online learning: patterns of engagement and interaction among in-service teachers. *Language Learning & Technology, 7*(3), 119-140.

Riel, M. (1992). A functional analysis of educational telecomputing: A case study of learning circles. *Interactive Learning Environments*, *2*(1), 15-29.

Stahl, G., Sumner, T., & Owen, R. (1995). Share globally, adapt locally: Software Assistance to locate and tailor curriculum posted to the Internet. *Computers in Education*, *24*(3), 237-246.

Stahl, G., Sumner, T., & Repenning, A. (1995). Internet repositories for collaborative learning: Supporting both students and teachers. *Paper presented at the Computer Support for Collaborative Learning* (CSCL '95), Bloomington, Indiana.