

UTILIZING CASE-BASED REASONING PRINCIPLES IN TECHNOLOGY

INTEGRATION EDUCATION

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It is a constant challenge for teachers to keep up with the ever-changing technological advances in the world today. Current teachers often struggle with how to use technology to enhance their students' learning experiences. Teacher education programs have a responsibility to offer both pre-service and in-service teachers strategies and methods for effectively using technology in their teaching practices. In this chapter, we describe how 8 teacher education programs collaboratively take an innovative approach to preparing teachers to integrate technology in instruction. This chapter discusses issues facing teachers in the area of technology integration as well as offers a system that resolves the issues and provides support to pre-service and in-service teachers and teacher educators.

Issues

Teachers are often required to work in isolation. As a result, there are four interrelated issues that arise. First, while teachers may spend time outside of their teaching experiences planning and collaborating with other teachers, when the time comes to conduct the lesson or the learning experiences, the teacher is often left to do the teaching alone. This means that teachers many times do not have the support or the assistance that they need in order to effectively use technology. Second, while many teachers have successful technology integration experiences, the successes occur away from other teachers and therefore, they do not have the opportunity to share their experiences. Third, the knowledge of how to effectively integrate technology into teaching practices is rooted in experience and is learned through the result of actions. This type of learning is difficult to elaborate and communicate to others. Finally, many school districts have only a few teachers who hold most of the technology integration knowledge. When these teachers leave the district, the knowledge that they have leaves as well.

These issues can all be addressed by designing methods to assist teachers in sharing their successes and failures with their colleagues; providing opportunities for teachers to learn from each other by sharing in the experiences of practicing teachers; recording and storing the experiences of teachers in order that the knowledge they hold is not lost; and increasing the size of the community of teachers integrating technology into their teaching practices. These principles can be met through the use of a system designed upon the principles of case-based reasoning.

Case-based Reasoning

Case-based Reasoning (CBR) is based on the idea that learning attained from a past situation can be adapted to fit a new situation. This is the natural response of humans faced with a problem. We tend to assess the situation, search our memory for past experiences similar to the current situation, seek out the experiences of peers and colleagues, and adapt and apply those lessons learned to the new situation. The CBR process can be broken down into the following steps (Allen, 1994):

1. Presentation of the problem. The current situation is presented as a case to be solved.
There are situational details that form the query for the search of the case base.
2. Retrieval of similar situations in the form of stories or cases. A search of the case base results in a retrieval of cases matching some or most of the situational features of the present problem.
3. Adaptation of the retrieved cases to fit the current situation. Possible solutions are adapted to fit the current situation.

4. Validation of the new solution. When the new solution is tested, the resulting success or failure will be added to the case base within the new story or case.
5. Update of the case base. The new case is stored as a new solution and is added to the case base for future use.

CBR has emerged as a promising method to build knowledge-based systems because of its simplicity (Watson, 1997, Watson, 1999). The concept of CBR follows the process that humans use to solve problems. A CBR system based on the nearest neighbor algorithm captures the knowledge gained through experiences and indexes those experiences according to pre-defined structural features. This allows previous knowledge to be retrieved and adapted to fit current situations and to solve problems. In contrast, rule-based systems require the extraction of “rules” in a knowledge domain in order to solve a problem. Any need to change the rules in a system can be time-consuming and costly. CBR systems, however, can be built without the difficult process of extracting the rules, and therefore can be much easier to adapt and build.

In addition to the simplicity of the system, another advantage of CBR includes the ability for the system to support problem solving in ill-structured domains, where rule-based systems are bound to fail. CBR systems also offer users concrete examples in the form of cases, which can assist the user in problem solving. Novice users can benefit from perusing the experiences of experts solving similar problems. Asking novices to study and apply the lessons learned from expert teachers allows the novices to be peripheral participants in the community of practice and giving them the opportunity to learn the language and practices of the teaching community.

The KITE Project

The Knowledge Innovation for Technology in Education (KITE) project is a collaboration of eight teacher education programs. The team is comprised of the University of Missouri-Columbia as the lead institution and seven other universities. The KITE project has developed a system utilizing CBR in order to teach pre-service and in-service teachers how to effectively integrate technology into their teaching practices.

The goal of the project was to build a CBR knowledge repository containing technology integration experiences, thereby enabling learning through sharing, communal understanding through storytelling, continuous exchange and creation of new knowledge, and collective problem solving (O'Dell & Grayson, 1998).

The KITE Knowledge Repository

The KITE knowledge repository has a three-tiered structure as shown in Figure 1. The first tier is a goal-based scenarios (GBS) learning environment. GBS is a learning strategy utilizing the concept that learning is most effective when the learner is placed in realistic situations, with clear contextual elements and the learner understands the reasons for the learning activities. A system using GBS can benefit from a case library by using the cases to set the scenario for the user. KITE has used GBS in developing the Technology Integration Learning Environment (TILE). The scenarios scaffold the learning by presenting a realistic situation for the learner to solve.

The second tier is the case base. With more than 1000 cases ranging across grade levels and subjects, the KITE case library allows users to seek out cases that are similar to their situation. The cases in a CBR system have three functions (Kolodner, 1993):

1. They provide contextual information to help with understanding or assessing a new situation.
2. They contain suggestions for solutions to problems.
3. They provide an opportunity for evaluation of suggested solutions.

KITE cases are captured through the use of “knowledge scouts”. Each of the seven partner institutions employed knowledge scouts, who were responsible for gathering technology integration experiences from teachers in their areas. They contacted local schools, met with practicing teachers and interviewed the teachers, asking them to share their technology integration experiences. The teachers shared their experiences and the transcribed interview was then indexed according to the KITE indexing structure. The cases were then proofread and a rubric was applied assure that the case information met the standards set by the case development team for case completeness. The case was then added to the knowledge repository.

The KITE CBR search engine is the final tier of the KITE system. The cases in a case library can be used for a variety of purposes, but without a search mechanism the cases would be worthless. The search engine is designed to function similar to the human thought process in that people tend to recall similar situations when encountering a new situation. The focus of the CBR search is to retrieve cases that have semantically similar meanings. This allows the user to present a problem case and find similar cases containing possible solutions to the problem case. A CBR search facilitates the CBR process for reasoning and learning.

As shown in Figure 2, there are four major components in the KITE CBR engine - 1) case library, 2) feature vector space, 3) user interface, and 4) search engine. First, all stories collected by the knowledge scouts in the case library are indexed into case feature vectors which the similarity between two cases can be calculated quantitatively. Second, a user querying the case

library will use the interface shown in Figure 3 to identify the aspects of the technology integration problem (context or situation) that are most relevant to their needs. Then, the user interface turns the problem into a query case that is converted into a query feature vector. Third, the query vector is matched against all case vectors in the high dimensional vector space using the nearest neighbor algorithm that finds the case vectors with shortest distances to the query vector. Fourth, the search engine returns all found cases ranked in distance. The shorter distance means a closer match. The user then chooses a matched case number to open the solution case.

Using KITE for Technology Integration Education

Currently, the project consortium has used KITE in several ways for technology integration education. In this section, we will describe how the cases in the KITE knowledge repository can be used as instructional resources to support technology integration education.

As an EPSS

An electronic performance support system (EPSS) is a system designed to provide knowledge-on-demand to users. An EPSS can electronically “provide whatever is necessary to generate performance and support at the moment of need [so it can be] universally and consistently available on demand any time, any place, and regardless of situation, without unnecessary intermediaries involved in the process” (Gery, 1991, p. 34). KITE is a web-based system, available online at any time or place in order to provide teachers with access to the technology integration experiences of more than 1000 of their peers. This allows teachers to search for similar technology integration experiences and plan their lessons and learning activities based on the lessons learned of other teachers in similar situations.

As an Instructional Resource

KITE has worked to develop several resources for teacher educators. The Technology Integration Learning Environment (TILE) is a tool designed to provide teacher educators with the support for using KITE cases and CBR in teacher education courses. TILE and other KITE activities have been used in several teacher education programs. Within the modules in TILE, learners are presented with instructional scenarios and asked to find and study KITE cases. They are then asked to propose new solutions for the scenario and to discuss their solutions with others. This practice allows the learners to compare and contrast the technology integration cases, looking for possible solutions to the current scenario.

As an example, Figure 4 shows a scenario that is based on a KITE case. Learners reading the scenario will evaluate the cases, compare similarities and differences with other cases, and prepare a new solution that combines the three cases evaluated. Here are several additional methods that the KITE consortium programs have used KITE as an instructional resource in their methods courses:

- Students conduct multiple case studies given a instructional problem.
- Students synthesize best practices and lessons learned from found cases given an instructional context.
- Students contrast realities from found cases with theories in the textbook.
- Students demonstrate how various technology use standards (e.g., ISTE) can be manifest from cases.
- Students develop lesson plans based on the same thread of stories.

As the Medium of an Online Learning Community

The technology integration cases in KITE are the foundation for building an online learning community. This community can facilitate the development of professional excellence and knowledge sharing. The online community of practice provides novice teachers the opportunity to share in the experiences of practiced teachers and expert teachers are forum for sharing the knowledge they hold. With the addition of online tools such as discussion boards, chat tools and other communication mediums, an online community can share and reflect on their experiences, sparking innovations and developing strategies for technology integration practices. By comparing and contrasting cases in the knowledge repository, members of the community are able to gain multiple perspectives on technology integration practices. They can take this knowledge gained to improve their own practices, based on the strengths and weaknesses that they discover.

Lessons Learned

Through the process of designing and developing the KITE knowledge repository, there arose a number of issues pertaining to the CBR system and the user interface. Development of the search engine, including case representation and case quality, and the design of the user interface were the most challenging issues.

Case Representation

The core of the KITE knowledge repository is the CBR based search engine. In order to accurately represent the knowledge held in the repository, case representation is of utmost importance. Since the CBR search engine is designed to look for cases based on the similarities to the context of the input situation, a critical task in the development stage was identifying the

1) domain features that would represent the domain of technology integration 2) the feature weights that would determine the importance placed on individual features in the context, 3) the options given for each index that would give value to search features and 4) the option distances that would determine how a case is similar to other cases.

The domain features selected to represent the domain of technology integration in KITE cases included the grade level, subject area, teacher's years of experience, goal of the technology integration activity and outcome of the activity. These features represent or index each story as a case. For example, a teacher looking for information about teaching 12th grade American history using the Internet and publishing software could input those features into a CBR search interface and would find cases similar to the context requested.

The weight of the features allowed importance to be placed on features that were more important to the KITE knowledge repository users. Teachers participating in a formal evaluation of KITE indicated that the most important features of a KITE case were the subject and grade level. If a teacher is searching for information about integrating the use of a digital camera in a 4th grade science activity, they would prefer to find cases related to science and lower grade levels rather than focusing on the technology used.

The options given for each index can be numerical, where the years of teaching experience can be selected from 1-35; or they can be non-numerical, with a finite list of text values. School location, for instance, would have the options for rural, urban, suburban, etc. These set the values used for determining the distance in the algorithm. The key to the CBR search is the similarities between cases. In order to calculate the similarity between two cases, the weighted average of all option distances is taken. A shorter distance between the two cases indicates more similarity.

The implications for the careful consideration of all these parameters can be seen not only in how cases are represented in KITE, but also in how the knowledge scouts conducting interviews gathered the information needed. Changes to the parameters after interviews have been conducted and stories gathered causes great difficulty in attempts to refine the cases and the search engine. The development of a structured indexing scheme allows the knowledge scouts to gather the important information needed for a complete and worthwhile case.

In developing the KITE index structure, a technology integration expert was consulted to propose the initial indexing scheme, followed by review from two teachers experienced in technology integration. The entire team then discussed resulting disagreements and adjusted the scheme as needed. A similar process was used in developing the weighting matrixes for the feature options.

After 300 KITE cases had been placed in the knowledge repository, extensive testing was done to determine search accuracy. If the search results did not match with the evaluation participant's expectations, the case values were examined to determine changes that should be made in the weighting. In addition to search accuracy, it was important to be sure that the results from the CBR search were high quality cases with important information provided.

Case Quality

The process for collecting KITE cases involved a knowledge scout who conducted an interview with a practicing teacher, then transcribed the interview and submitted the interview to the case development team. The case development team then indexed the case according to the structure developed and input the case into the knowledge repository. The quality of the case therefore relies on the ability of the knowledge scouts to gather accurate and complete information and the ability of the indexers to appropriately index the case.

A number of measures were taken throughout the project to assure that the knowledge scouts collected quality stories. During the first year of the project, a needs assessment was conducted and the results were used to train the knowledge scouts. Support mechanisms were put in place. A job aid was developed which included an interview protocol. A web-based tutorial was developed in order to help new knowledge scouts learn the process. The tutorial included interview tips shared by experts, information on the types of questions to be asked in the interview and techniques for interviewing, good examples of indexed stories to provide a benchmark for scouts, and a set of trial stories for knowledge scouts to practice indexing. We found that knowledge scouts who participated in indexing other knowledge scout interviews were able to be more successful in conducting interviews. They were more aware of the information needed to complete the case and more familiar with strategies that they could use in interviewing.

In addition to the support tools developed, a rubric was created to judge case quality. The rubric counted the number of predetermined required index terms required in order to contain sufficient details to adequately portray the technology integration experience. When the rubric was first developed, a “spot-check” was done on cases already in the knowledge repository using a randomly selected 20% of cases available. We found that a surprising 49% of cases did not pass the rubric. Following this check, we took steps to remedy this by meeting with all the knowledge scouts and conducting a more intensive training session. Successful scouts were asked to share their experiences and the case development team determined to provide the scouts with more immediate feedback on the cases that they submitted. An updated job aid was also provided.

The rubric was not only used to check cases once they were in the repository, but the knowledge scouts were also asked to apply it to each case prior to submission. The passing rate for cases following these measures has increased to 84%.

Interface design

Historically, CBR research has focused on the computer science or artificial intelligence perspective with little attention given to the design of a user interface. In addition, most of the users of the KITE system were not familiar with the concept of CBR or even capable of using CBR to conduct searches. To remedy this situation, we adopted the rapid application development approach (Robinson, 1995) to the design and development of the system. The search engine has been through at least five iterations of “molding” and “tweaking” to reach its current format today. Feedback was collected from panel reviews and formal usability testing with pre- and in-service teachers. Errors and omissions were detected and fixes were made as needed throughout the development process. This process has led to the development of a more user-friendly system, which can be used for learning and sharing of knowledge by users inexperienced with the principles of CBR.

Conclusion

The sharing of experiences for learning and innovation has been a part of the human culture across the ages. Stories are the most natural method for sharing experiences as the human brain is designed to better understand complex issues when the information is set into context. The KITE knowledge repository is a useful tool for capturing, storing and sharing the experiences of teachers in many different locations. The CBR system allows members of a community, spread across time and place, to learn from each other and improve their teaching practices. Cases that

are stored in the knowledge repository can reach a wider group of people and can be kept in the “memory” of the system, preserving the experiences of its members.

The lessons learned through the use of CBR for education and knowledge sharing, as seen in the KITE project, can be applicable to any number of domains. The KITE system has been designed to be adapted in order to fit a variety of different needs. Future plans for systems at the University of Missouri include a field experience system for pre-service teachers to share the knowledge that they have gained in clinical experiences in local schools and an entrepreneurial experience system for people starting small businesses. By utilizing the concept of CBR, knowledge gained by one person can be explicated and stored in the memory of the system. This knowledge can be easily accessed and adapted to fit the needs of many users, expanding the possibilities for learning and self-improvement.

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Figure 1: The three levels of the KITE knowledge repository.

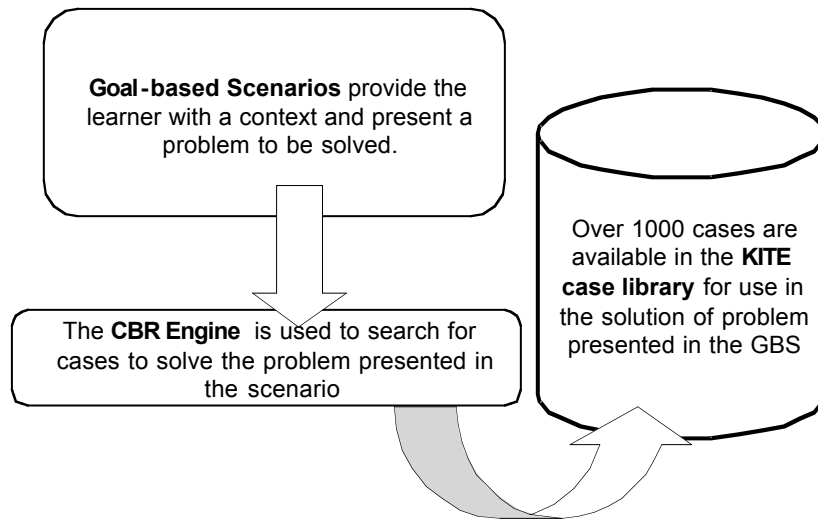


Figure 2: Major components of the KITE CBR engine

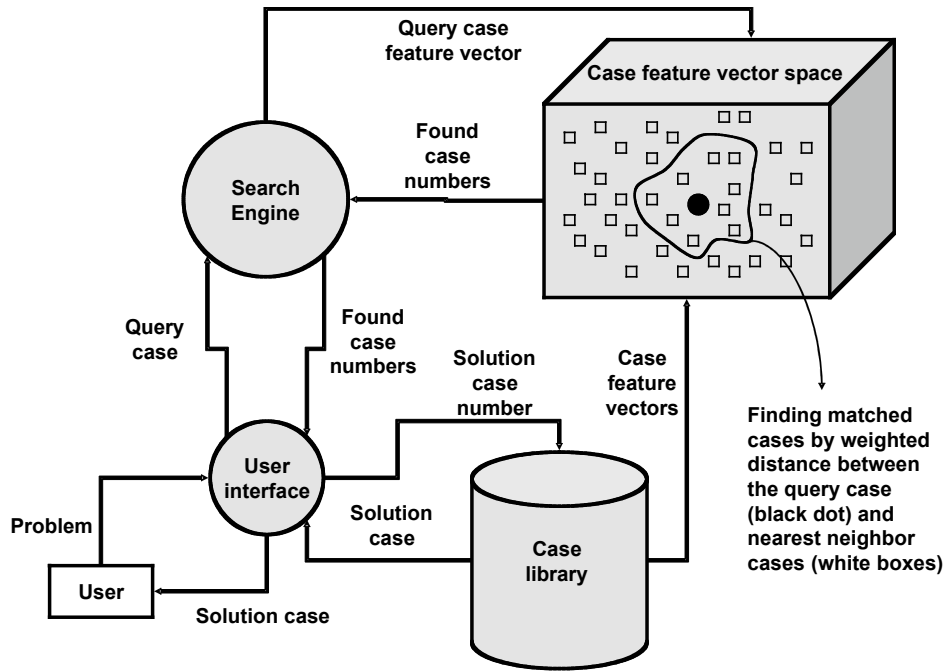


Figure 3: A query case example: A 4th grade Math teacher in an urban elementary school looks for previous cases in a similar instructional situation involving students using graphic calculators and computer spreadsheets in laboratory experiences.

KITE Search - Microsoft Internet Explorer

Address: http://kite.missouri.edu/kite/ad_search.htm

KITE Technology Integration Case Library

Keyword Search Super Search Browsing HOME SIGN GUEST BOOK VIEW GUEST BOOK

❖ Super Search Directions ❖


What kind of cases are you looking to find? Select from one or more of the following options to begin your search.

School location	urban(major city)
Grade Level of Students	grade 4
Subject/Unit	Math
Technologies used in Lesson	graphic calculator; spreadsheets; Lookup
Planned Activities in Lesson	laboratory experience; Lookup


[More Search Options](#)

Number of retrieval results per page: 10 Search Reset

Figure 4: Sample of a TILE scenario.

 **Scenario 1 - KITE case 4022-1**

"Bob" is an English/Language Arts teacher working with 12th grade students. The unit they are studying is Asian literature and the students are learning that the books were focused on teaching people how to live their lives. Bob is tired of requiring research papers from seniors who are bored and ready to do something more exciting and challenging. Bob decided to assign the students the task of creating a public service announcement that would persuade other people to change some aspect of their lives.



Students worked in groups to research the information for their topic, to write a detailed script for the announcement, and to create a storyboard. The students presented their work to the rest of the class for evaluations. The students then revised their work based on the feedback they received from their peers. Following the re-write, the students were given digital cameras and they filmed their announcements. The film was edited on the library's computer using special software. After some minor problems, such as sound issues, the final announcements were assessed for quality, persuasiveness and whether the announcement would be realistic to the audience.

Bob's most important objective was to help the students realize that language is a powerful tool and that the students have the ability to persuade other people when they have knowledge of their language.