DyKnow™

Encouraging Active Learning: Best Practices and Supporting Technologies

There is a nationwide call for educators to emphasize instructional methods that encourage student engagement during class. As one notable example, the National Research Council suggests that educators should provide "active learning environments for all students, even in large section, lecture-dominated courses" (National Academy of Sciences - National Research Council, 1999). Based on their own experiences in the classroom, and with the support of such organizations as the National Research Council, many instructors have started looking for ways to exchange the traditional classroom model, which involves a teacher lecturing in front of large groups of passive students, with a new one, which involves students taking an active role in their own learning.
Active learning can be defined as "any instructional method that engages students in the learning process" (Prince, 2004). For the purposes of this paper we will concentrate on student-focused activities that are interweaved with more traditional lecture practice, as suggested by Prince (2004).

The remainder of this paper describes the motivation behind the use of active learning, provides sample strategies for fostering active learning, and discusses ways to overcome obstacles involved in providing active learning activities in a class. Finally, the paper introduces DyKnow Vision™, a software tool that can be used to promote an active learning environment in any classroom. Early evaluation data indicates that students feel actively engaged in the material when teachers use DyKnow Vision software to support techniques which foster active learning.

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2. The Motivation behind Active Learning

Novel "active learning" techniques are being proposed by classroom instructors in a wide variety of subject areas. This suggests that active learning strategies are being developed to meet a need that is recognized in a variety of contexts.

A typical story is told by Jonte Bernhard, a Physics teacher in Sweden (Bernhard, 1999). Bernhard was surprised to find that a large proportion of his students were unable to answer a simple conceptual question on one of his exams. Although many of these students could solve problems involving complex calculations, they appeared to have fundamental misunderstandings of basic concepts such as the difference between velocity and acceleration. These misunderstandings prevented the students from correctly answering conceptual questions.

Bernhard and others believe that the students' struggle with conceptual material can be explained by cognitive science. According to cognitive theory, people organize their knowledge into mental models. Because students enter a course with existing mental models (which are sometimes incorrect), it is difficult to establish new models unless the learner is driven to confront the old ones. Research has shown that creating a useful mental model requires new information to be presented in a way that challenges previous beliefs. At the same time the new information must be understandable and plausible to the learner.

After reviewing the research, Bernhard came to the conclusion that traditional lecture techniques do not address these needs (Bernhard, 1999).

Like many other instructors around the world, Bernhard decided to explore active learning techniques as a way to overcome the problems associated with traditional lecture techniques.

3 Active Learning Strategies

3.1 What are the benefits of active learning?

Evidence indicates that a typical student's attention span for listening to a speaker is about 15 minutes. After that, a student's ability to focus drops dramatically. In fact, studies have shown that students recall 70% of what is said in the first ten minutes of a traditional lecture, and only 20% of what is said in the last ten minutes (Prince, 2004). Furthermore, instructors tend to lecture at a rate of 120-140 words per minute, while many students can only take notes at 20 words per minute (Bonwell, 1999). Active learning practices break teacher-centered lectures into 10-15 minute chunks, separated by activities that allow students to create or improve their notes or otherwise engage with the material. This allows students to regain focus, catch up, and assimilate what they have learned into their existing mental models or to create new mental models (Prince, 2004).

In addition to breaking teacher-centered discussion into small chunks, active learning strategies rely on fostering student engagement. According to one proponent of active learning techniques, Eric Mazur, a Physics professor at Harvard University, "The students' energy and enthusiasm during the [active learning activities] are contagious: once one has experienced [this excitement], it is difficult to revert to lecturing to a passive and mostly silent audience" (Mazur, 1997a). A large body of evidence indicates that student engagement with material also has an effect on a broad range of learning outcomes. Studies cited by Prince (2004) show that, in some cases, scores on exams that measure conceptual understanding were two times as high in classes that promoted engagement as compared to traditional classes covering the same material. An additional benefit of many active learning practices is the immediate feedback they provide to teachers. The results of student activities can indicate topics that are not clear. This allows the teacher to immediately adjust the lesson plan (Bonwell & Eison, 1991; Mazur, 1997b).

The authors of How People Learn: Brain, Mind, Experiences, and School confirm that active learning approaches are sound when considered from the point of view of contemporary learning theory; they further point out that interactive technologies can be used to create environments where students "learn by

doing, receive feedback, and continually refine their understanding and build new knowledge" (Bransford et al., 2000).

3.2 What types of activities promote active learning?

One simple way to introduce active learning into a traditional lecture is to allow students to pause for two minutes during class presentations to consolidate their notes after each major topic is presented (Bonwell & Eison, 1991). Studies have shown that students who periodically summarize what they have heard do better then those who merely review their notes. However, novice students do not always know how to summarize well. Therefore, they may need to be coached in this practice, and the instructor may wish to provide the students with summary creation guidelines (Bonwell, 1999). Allowing students to discuss their summaries with their neighbors helps them to create even more complete notes, while also helping them to discover misconceptions. A more formal, and group-oriented, technique is called a "Feedback Lecture". When using this technique, class presentation is divided into several "mini-lectures", separated by study periods in which small groups follow a study guide and discuss the material that was presented (Bonwell & Eison, 1991).

Several other active learning techniques involve a focus on thought provoking questions. The "Think-Pair-Share" technique involves pairs of students working together to solve a problem or answer a question supplied by the teacher. After pairs have discussed the question, they share their answer with the larger class. Like many of the techniques discussed here, Think-Pair-Share works well in both large and small classes, allowing more students to be involved in the discussion and minimizing student embarrassment because the initial discussion is with a single fellow student (Butler et al., 2001).

Several active learning techniques are specifically focused on creative writing activities. A typical activity is often called a "one-minute-essay" or "minute-paper". Students are asked to provide a short response to a general question such as "What is the most important thing you learned today in class?" These writing exercises may be used at the beginning or end of a class period to assess preparedness or understanding. Alternatively the exercises may be interspersed during a longer discussion (Butler et al., 2001). In addition to engaging students, these exercises can help students practice writing skills (Bonwell, 1999).

Eric Mazur developed a technique called "Peer Instruction", which involves the use of "ConceptTests". ConceptTests are conceptual questions that students can answer by a show of hands. After a quick class vote, students discuss their answers with peers, and then vote again. The results of these votes lead to a class discussion. This technique has the benefits of small-group and class discussion mentioned earlier, and also allows students to think through complex conceptual questions similar to those they may experience on an exam (Mazur, 1997a).

Using DyKnow in the Classroom Scenario One

Mr. Ritchie, a fourth grade teacher, has found a great website that allows students to experiment with fractions by using an interactive balance scale.

He embeds the web page into a DyKnow panel. At the bottom of the panel are questions he has created about the web page. Students interact with the web page to solve the problems and then write their answers in the area provided. When the students are done, they submit their work to Mr. Ritchie electronically through the DyKnow system.

Mr. Ritchie makes comments on each student's solution as it comes in, and uses DyKnow to send the marked-up work directly back to each student. While commenting on the work, Mr. Ritchie notices some common mistakes. He anonymously shares a student answer with the entire class. Mr. Ritchie modifies the student's original answer as he models solving the problem correctly. This leads to more questions from the class. Mr. Ritchie now spontaneously displays a blank DyKnow panel and follows up with more examples and practice problems.

3.3 Addressing typical instructor concerns related to active learning

It is not unusual for instructors to be concerned about the amount of time it will take to develop new active learning activities. However, while teacher preparation is necessary to create a useful active-learning strategy, it appears not to take much longer to prepare for a class session incorporating active learning strategies then it would to compile material for a traditional lecture on a new topic (Fagen et al., 2002). Furthermore, some successful activities can be reused across a number of different courses (McConnell, 1996).

Instructors may also be concerned about the time lost for traditional lecture and the possible resulting decrease in the quantity of material that can be covered. However, once students are introduced to active learning practices, the instructor can rely on the students to cover basic material by reading their textbook. Students will learn to come to class ready for further discussion, especially if they know they will be given a simple quiz at the beginning of class (Fagen et al., 2002). One of the most common instructor concerns is that students will not understand the value of active learning techniques. Instructors may also fear that students will not participate during activities as expected. To combat these problems, Bonwell and Eison (1991) recommend bringing active learning strategies in to the classroom gradually. They suggest starting with well-structured, low-risk activities that can be carefully planned. Further, it helps if these initial activities are clearly focused on one topic, and are not too abstract or controversial. Students are more likely to become actively involved with these types of activities if they understand the teacher's goals and expectations. "Preparing students to participate in an active learning environment" (Modell, 1996) provides specific suggestions to help students adjust to an active learning environment.

4 Using DyKnow Vision Technology to Facilitate Active Learning

Dr. Dave Berque, A Computer Science Professor at DePauw University, was concerned that students spent most of their time and energy copying notes rather than interacting with material during a traditional lecture. In response, he designed a system to help students interact more directly with the teacher and the material during class. A key objective of this system was to facilitate useful note taking, by allowing students to spend less time copying complex diagrams and mechanically transcribing what the teacher was saying, as well as helping students to avoid note-taking errors. Rather than eliminating student note-taking, the goal was to transform the nature of student note-taking from rote copying to higher level analysis. When using the system students could annotate on top of, or alongside, the teacher's notes, allowing for the benefits of active note-taking. An enhanced version of this software is now called DyKnow Vision. As we will describe below, the current version of DyKnow Vision has evolved beyond an interactive note-taking system to a platform that facilitates a wide range of active learning approaches.

Using DyKnow in the Classroom Scenario Two

Several members of Mrs. Delphiki's ESL class are struggling with finding the main idea in long English texts. Mrs. Delphiki believes this is an opportunity for students to learn from each other. She also believes she can create an opportunity to engage some of the quieter members of the class in informal oral discussion.

Mrs. Delphiki chooses a typical reading and pastes it into a DyKnow notebook. She then asks the class to highlight the sentence that contains the main idea of the first paragraph. After a few minutes, she asks for volunteers to describe their answers.

Several students are shy and do not join the conversation. So, Mrs. Delphiki initiates an anonymous poll, asking each student to choose the option corresponding to the sentence they believe contains the main idea. Not only does everyone participate eagerly in the polling, including the quieter students, they also feel more confident recognizing that there are several different opinions. Naturally a lively class discussion unfolds. One member of the class volunteers to try highlighting the main sentence in the next paragraph. Mrs. Delphiki encourages her to describe her thought process in choosing the correct sentence. The student circles several sentences, explaining why she does not believe they describe the main idea of the paragraph.

Finally, she highlights the correct sentence. As other members of the class witness her thought process, they begin to understand the text better.

DyKnow software is used in varied hardware environments including traditional computer laboratories, classrooms in which students have laptop computers, and environments in which students have Tablet PCs or other pen-based input devices. In each case, the system allows the students and teacher to share written information during class. For example, the teacher can extemporaneously draw sketches directly on the surface of a pen-based computer or electronic whiteboard. Alternatively, the teacher can use a keyboard to type material, and can import material (including graphics, PowerPoint slides, and live Web content) that was prepared ahead of time. All information sketched, typed, or imported by the teacher immediately appears on each student's display (see sidebar, Scenario One).

Each student can type or write private annotations alongside the teacher's material. Generally, these annotations are not visible to others. However, one or more students can temporarily be given the ability to make annotations that will be transmitted interactively to the entire class as each stroke is drawn. Alternatively, the students can submit portions of their completed work (for example, a section that contains a solution to a problem) to the teacher who can then display this material for the entire class to see and discuss. Because of this process, class sessions have the potential to unfold as highly interactive activities. In an ideal scenario, the teacher introduces new material to the class while the students take additional notes that are intermixed with the instructor's content. Then the instructor asks the students to interact with the material by typing or writing answers to questions that are related to this material. The instructor then uses the system to share some or all of the student's answers with the class, responds to questions about these answers, offers alternatives, and determines if the class is ready for new material. At the end of the class each student's electronic notebook can be printed or saved electronically for later study. Since each student's notebooks are stored on an internet accessible server, students can even review notes from previous semesters. Sections of any electronic notebook can also be replayed in a stroke-by-stroke fashion allowing a student to review how a complex diagram evolved. Thus, unlike traditional notebooks, DyKnow notebooks capture "process" as well as "content".

4.1 DyKnow features which support active learning techniques

Several of DyKnow Vision's interactive features support active learning particularly well. For example, Peer Instruction techniques, and other strategies that involve obtaining a quick class vote, are easy to facilitate with DyKnow Vision. An anonymous polling feature allows students to respond to a multiple-choice question (see scenario two in the sidebar for an example of using the anonymous polling technique). Student responses are instantly sent to the instructor, who can produce a pie-chart or bar-chart with the click of a button to show students the class's response.

Instructors can also embed questions or exercises into course notes which are transmitted to each student's computer. Students can respond to these individually or as part of a group. Because DyKnow is a graphical tool, students may draw diagrams or cut and paste pictures from other applications. The teacher can permit two or more students to type or draw on the page at the same time using their own individual computers during group work. When students are done, the teacher may collect their work. If desired, the teacher can display examples of student work anonymously to the entire class, and further annotate or even erase incorrect portions of student answers and replace them with the correct sequence. The instructor may also give control of the session to one or more students, allowing them to illustrate their questions or responses for the entire class.

All instructor-provided notes, student annotations, and student exercises, including those of other students shared by the teacher, are included in each student's DyKnow notebook. These notebooks can be accessed from any web-enabled machine while studying. Because students develop and refine mental models during class, this record of the class may be a particularly useful study aid because it can bring back to memory the discussions and other activities that occurred in class.

4.2 Student reaction to the DyKnow environment

Students and teachers were so excited about using DyKnow Vision at Park Tudor, a private K-12 school, that they decided to make a video about their experience with DyKnow (Ritz, 2005). The video shows how Park Tudor students use DyKnow Vision to keep up with class and engage in classroom material rather than being consumed by mechanically taking notes. The video also highlights difficulties many students have with volunteering answers. Without DyKnow, according to the video, some students find it hard to volunteer in class. A student in the video states "Many times they are afraid their answer is incorrect, and others just have stage fright". The video also notes that it can take several minutes of class time to have a student come up to the board in a traditional class. With DyKnow Vision, "volunteering is painless and fast."

A recent survey of 81 college students who have been using DyKnow in the classroom indicates that higher-education students also appreciate the active learning approach that can be fostered by DyKnow Vision (Berque, 2005). In total, these students have taken 431 courses using the system. Ninety-two percent of the respondents place moderate or significant value on doing in-class exercises to practice with content using DyKnow Vision, and 71% indicate that they value seeing the work of other students. Further, 95% of respondents indicate that using DyKnow enhances their understanding of material presented in class, and 87% indicate that it enhances their understanding of the material when reviewing it outside of class.

Seventy-five percent of students agree that class time is more valuable when DyKnow is used, and 98% indicated that DyKnow has a positive impact on what they learned in their major or minor. One student summed up these feelings by saying "I definitely prefer classes that use DyKnow to non-DyKnow classes, and I feel that my attendance is even better because I am more involved in the class and enjoy being there more." Clearly, an active, engaging approach combined with the use of the DyKnow software encouraged such positive student perceptions. Students particularly appreciate class sessions in which teachers use the more interactive features of DyKnow Vision. One student emphasized "if a teacher is very interactive with the program (gives quizzes, has in-class exercises, etc) then the program really shines. I think professors/instructors should be strongly encouraged to support this kind of interaction."

This insight matches well with active learning research: A tool such as DyKnow Vision can be useful in supporting and enhancing the types of activities that promote active learning, if the instructor has created a set of activities that complement the material being covered. Students appear to recognize the way that DyKnow helps them become more engaged in the material, and indicate that they are more likely to bring up questions or consider alternate solutions to problems in courses facilitated with DyKnow. One noted: I really enjoy DyKnow and I think it is a very useful program. I can't imagine my classes without it. I think it allows for professors to spend more time on the class material since they can prepare the slides before hand and do not have to spend time writing notes in class. It allows for students to have a good set of notes because they can add to what the professor says in class and I think it is easier to go back and ask questions about the material because the student has the copy of the slide(s) that they do not understand. I like the fact that students can submit answers to class problems. This type of participation allows for students to see different solutions, which in [Computer Science] there is always more than one way to solve a problem and write code.

4.3 Teacher reaction to DyKnow

Faculty at a small liberal arts college which makes heavy use of DyKnow software also responded positively to the features of DyKnow Vision which support active learning (Berque, 2005). In a survey of ten faculty members who have taught a total of 90 courses using DyKnow Vision, most teachers report that they use DyKnow Vision to transmit problems or exercises for students to complete, allow students to submit panels anonymously, use multiple-choice polling to get anonymous student feedback, and have students give their own presentations using DyKnow. All ten faculty members placed moderate or significant value on the ability to allow students to practice with content, as well as the ability to allow students to see how their peers solve problems during class. All of these practices foster an active-learning environment.

Six out of ten indicated that using DyKnow Vision enhances their ability to use pedagogies they already valued, and six reported that using DyKnow Vision has

allowed them to change their teaching style. Six out of ten indicate that class time is more valuable when DyKnow Vision is used (the remainder were neutral), and perhaps surprisingly in light of the fears many teachers have about active learning practices, five out if ten indicated that they cover more material when DyKnow Vision is used. All ten teachers indicated that "Overall, DyKnow Vision has a positive impact on student learning in my classes." According to one instructor: I believe my students learn more when I use the system. I also believe class is more enjoyable for both myself and the students when DyKnow Vision is used. I feel more connected to my class, and I believe my students are more connected to me and to the material.

5 Conclusion

Although "active learning" can describe a wide variety of classroom activities, all of the activities share some common traits: a focus on student engagement, and a philosophy that encourages students to take an active role in their own learning. Critically assessing students' current understanding and developing a plan that considers your students and the subject matter you teach can help you start on a path toward leveraging effective active learning practices. An interactive tool such as DyKnow Vision can help to more easily create engaging, interactive, student-centered experiences.

6 References

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About DyKnow

A leader in interactive education, DyKnow combines sound teaching with intuitive technology to create the most flexible and effective solutions for teaching and learning. DyKnow is committed to helping teachers maximize class time and foster collaboration while also minimizing electronic distraction. By promoting effective studying and gathering student feedback teachers can feel confident in students' academic success.

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