



*Providing Valuable and Timely Feedback:
Best Practices and Supporting Technologies*

This paper describes the role feedback plays in learning, and introduces the types of feedback that have proven to be the most useful in common classroom situations. Good instructional practices for using feedback are discussed. Finally, the paper introduces DyKnow Vision™, a software tool that can be used to promote an engaging learning environment while incorporating several mechanisms for providing prompt and effective feedback in any classroom. Early evaluation data indicates that instructors frequently use the DyKnow Vision system to assess student work at levels not possible in a paper-based classroom, and that students believe that use of the DyKnow system helps them to understand concepts better.

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2 Providing Useful Feedback

2.1 Background

Cognitive science stresses the importance of helping learners create useful mental models while learning. Providing opportunities to practice and receive corrective feedback is an important step in helping learners correctly store and link related information so that it can be retrieved usefully. It is also important for learners to monitor their own learning and develop study skills that work for them. Providing feedback on student’s current performance can have the additional benefit of helping students develop good study techniques (Ertmer & Newby, 1993).

Specific feedback on student behaviors or activities can take several forms. “Ability” feedback tells students that their success or failure is due to their own innate abilities. For example, an instructor might say “I love the collage you made. You’re so artistic!” On the other hand, “effort” feedback indicates that students’ performance is due to the effort they have put in to a task. For example, an instructor might say “That was a great report. I can tell you put a lot of time into it.” Both types of feedback can be either positive (rewarding correct answers or behavior) or negative (indicating incorrect or undesired answers or behavior). Research indicates that positive ability feedback will raise students’ self-esteem, and encourage students to persist longer on new tasks than those who receive high effort feedback. However, students who do not perform well are discouraged by ability feedback, while low-performers who receive effort feedback appear to recognize that they will succeed with more effort and will continue to try at similar tasks in the future. Furthermore, students appear to respond better to negative effort feedback (which indicates that if students put in more effort, they will succeed) than to negative ability feedback (which indicates to students that

they are not succeeding at a task because they do not have an innate ability in that area). Therefore, experts recommend that instructors give a lot of positive ability feedback and negative effort feedback. General feedback (such as “good work”) does not give students an indication of the reasons for their success or failure on a task, and therefore is of less value in aiding learning. Unfortunately, many instructors rely heavily on general feedback (Burnett, 2003; Foote, 1999).

One impediment to a students’ ability to become an effective learner is “judgment bias”. Judgment bias is the tendency to inaccurately gauge the level of one’s own knowledge. Most students overestimate their ability to solve difficult problems, and underestimate their ability to solve easy problems. Both types of estimate errors are especially pronounced in students with poor performance. Unfortunately, when students do not correctly gauge what they do and do not know, they are not likely to pay attention when topics they misunderstand are discussed. They are also unlikely to concentrate on material they have not truly mastered. Offering students the ability to practice using what they have learned and receive feedback can help them to reduce their judgment bias. This, in turn, can help them become better learners (Flannelly, 2001).

2.2 Useful Techniques for Providing Feedback

The most useful feedback is well planned, constructive, and specific to the task at hand, as well as being timely, accurate, and encouraging (Konold et al., 2004). This section describes feedback techniques that can be used by instructors in specific situations.

Research suggests that instructors use “Differentiated Feedback”, varying the type of feedback they give based on four types of typical student responses. When using the Differentiated Feedback technique, a simple acknowledgement is recommended when a student gives a correct answer quickly and firmly (e.g. “Yes, that’s correct”). If a student gives a correct answer hesitantly, the instructor should give a more detailed response (e.g. “That’s correct. We know that ‘walked’ is the verb in this sentence because it describes the action.”). This will reinforce what the student has learned and add to the student’s understanding, as well as acknowledge the correct answer. If a student responds incorrectly because he or she does not understand the material, the instructor may use prompts or cues to help guide the student to the correct answer. However, if the instructor believes that the student has answered incorrectly because of carelessness, the instructor should simply provide the correct answer and continue with the lesson. If some students continue to give incorrect answers based on a lack of knowledge, the instructor may provide additional explanations, examples, or practice activities (Konold et al., 2004).

A technique used to further increase the educational value of providing feedback is called “Instructive Feedback”. Instructive Feedback involves providing additional information in response to students’ correct answers. This allows the

instructor to fit more information in each lesson, and also helps students to link new information together. Students are not required or expected to respond to the additional information provided as part of the instructive feedback. There are three types of Instructive Feedback. "Expansive instructive feedback" provides additional information. For instance, after a student provides the definition of a term, the instructor might confirm their response and provide some synonyms for the word, thereby expanding the student's vocabulary. An instructor may also give "parallel instructive feedback" by adding another question or problem that would have also required the response the student has just given. For instance, if a student can correctly identify a picture of a giraffe, the instructor can then show the class the written word "giraffe" and say "That's right. And this is the word giraffe". Finally, an instructor may use "novel instructive feedback". This type of feedback provides additional unrelated information. For example, if a student correctly identifies the shape of a square, the instructor can respond "That's right! And the color of the square is blue" (Konold et al., 2004).

The types of feedback discussed so far are particularly appropriate for use during class sessions. However, homework and written assignments also provide opportunities for the use of effective feedback. If written feedback is provided, it should prominently include at least some positive comments, as well as providing clear, useful corrective feedback. This may be done by highlighting incorrect sections as well as giving specific information on the nature of the error along with advice about how to correct it (Konold et al., 2004).

The use of "elaborated feedback" (feedback that goes beyond merely indicating whether the students work is correct or incorrect) when material is challenging, or when student progress in a particular area is slower than expected, may help individual students master skills more quickly without taking up time used for whole-class instruction. Elaborated feedback is usually carefully planned. After determining the types of errors made, the instructor returns the work to the student and asks for corrections. When the student returns the work for a second time, the instructor should note any changes to the types of errors. The instructor can then describe the type of error made, and can model the correct approach using a similar example. Finally, the instructor can ask the student to try some similar problems independently. Once all types of errors have been worked through, the instructor can summarize the errors and discuss how the student can do better in the future. The instructor should emphasize high expectations for the student's future performance (Konold et al., 2004).

An instructor may also use tests as a mechanism to provide feedback to students. In the article "Test Feedback Class Sessions" (Kher et al., 2002), the authors describe a four-phase approach to returning tests in a way that provides useful feedback to students and makes test-return "a positive part of the learning process". These strategies involve respecting students' privacy and concerns about the tests, while allowing instructors to quickly identify and discuss the

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areas students did not understand well. This is an opportunity to strengthen understanding of the material and raise study and test-taking skills. For example, in addition to addressing particular errors made by class members, the instructor may take the opportunity to advertise the existence of the campus writing center, or ensure that students understand that they can ask for clarification on test problems. This in turn can help students acquire techniques that enable them to reduce judgment bias and evaluate their own learning more effectively.

3 Using DyKnow Vision Technology to Facilitate Giving Feedback

Dr. Dave Berque, a Computer Science Professor at DePauw University, was concerned that students spend much of their time and energy copying notes rather than interacting with material and the instructor during a traditional lecture. In response, he designed a system to help students and instructors interact more during class. Rather than eliminating student note-taking, the goal was to transform the classroom experience from rote copying to higher level analysis. When using the system students could annotate on top of, or alongside, the instructor'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 interactive classroom experiences and makes it easier for the instructor to provide prompt and effective feedback on a regular basis.

DyKnow software can be 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 instructor and students to share written information during class. For example, the instructor can extemporaneously write or sketch directly on the surface of a pen-based computer or electronic whiteboard in response to students' questions. Alternatively, the instructor 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 instructor immediately appears on each student's display.

Each student can type or write private annotations alongside the instructor's material. Generally, these annotations are not visible to others. However, one or more students can temporarily be given the ability to lead the class, making annotations that will be transmitted immediately to the entire class as each stroke is drawn. Alternatively, instructors may collect student work and grade it, then return it directly to the student or display it to the entire class. Homework may also be collected during classes and returned outside of class hours. The next time students log in, they will receive their feedback. Whether feedback is given inside or outside of class hours, the instructor retains the ability to annotate on top of student work, allowing the instructor to provide immediate feedback or enhancements.

At the end of the class each student's electronic notebook along with graded work that has been returned by the instructor can be printed or saved electronically for later study. Since student 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."

3.1 DyKnow Features Which Facilitate the use of Effective Feedback

As mentioned above, students can submit portions of their completed work (for example, a section that contains a solution to a problem) to the instructor. The instructor can annotate the answers with corrections and feedback, and then return them immediately to each student via the DyKnow Vision software, or may pull up one or more interesting examples to share with the entire class. For example, if many students have a misunderstanding in a similar area, the instructor may post a typical student response anonymously to the class, then erase the incorrect portion and complete the problem correctly. This allows feedback to be given to the entire group, while modeling the correct thinking process. This interactive feedback mechanism also allows the instructor to provide personalized Directed Feedback. It is easy to spontaneously add new content into a DyKnow notebook. If student responses indicate that understanding is lacking in a particular area, Elaborated Feedback can be given either privately to one student via returned DyKnow panels, or to the entire class. If students appear to have mastered the content well, Instructive Feedback can be given to the whole class, allowing the instructor to springboard off student responses into new areas of instruction.

A similar technique can be used to offer homework or quizzes using the DyKnow system. Students may work on a set of questions or solve a problem within a DyKnow notebook. Students may voluntarily submit the portion of their notebook containing their work. If desired, the instructor may also retrieve work directly. Either way, the instructor may elect to collect anonymously (to get a general idea of how students are doing) or to retrieve with identifying information (for purposes of grading or tracking individuals' progress). Once again, the instructor may annotate student work and provide feedback in a variety of manners. Once the instructor has completed grading, the class's work can be sent back to all students in one quick action during or outside of class hours. When facilitating a class discussion of results, the instructor may choose to post examples of student work anonymously as part of the DyKnow session. These examples may show exemplary student work, or may be used to highlight common mistakes. For example, an instructor may use DyKnow Vision to display a student solution to a math problem which is technically correct but doesn't

show all steps. The instructor could then add in the missing steps. All student notebooks will include a copy of the modified answer, to help guide students in their own problem solving in the future. (See the scenario in the sidebar on the following page for a more detailed example of how an instructor may provide immediate and flexible feedback using DyKnow Vision.)

A particularly interesting aspect of DyKnow notebooks may allow instructors to gain further understanding into students' thought processes. Because all notations are captured by the system, it is possible for an instructor to use a replay feature to play back student work stroke by stroke. This allows the instructor to see if students have repeatedly erased or modified an answer. They can also see the order in which students went about solving the problem. For instance, if a student first wrote the answer to a math problem and then jumped back afterwards to "show his work" the instructor may conclude that the student did not really understand why it is necessary to show his work. The replay feature is also particularly useful in subjects such as written Japanese, in which the order and direction of strokes drawn is very important.

Using DyKnow in the Classroom Scenario

The teacher begins a data structures class by importing several pages of previously prepared notes that explain how to delete a node from a binary search tree. As the teacher imports each page of notes to his screen, the notes are simultaneously displayed on each student's screen. The students use their pens to make additional annotations based on the teacher's explanation; for example several students make annotations when the teacher orally explains the worst case running time of the deletion algorithm. Next, the teacher imports a quiz question that requires students to redraw a binary search tree after several items have been deleted. The students begin to work on the problem by sketching diagrams on their computers. Since the teacher has not given control to any student, these annotations are made locally and are not shared with others in the class. After five minutes, the teacher presses an icon that captures each student's work up to this point. The teacher scans this work quickly, and sees that many of the students are having trouble deleting the node that has two children. Based on this, the teacher makes a few suggestions to the class, and then asks the students to work with a neighbor to revise their solutions. Students lean toward each other sharing their original answers and discussing the teacher's suggestions, and some of the students erase their work and make changes. After another few minutes the teacher again collects the students' answers so that their progress can be assessed. At this point the teacher imports a previously prepared "answer key", thus making it available to the entire class.

When grading the quiz, the teacher can see the student's original solutions as well as the solutions produced later by the pairs.

(Berque et al., 2004)

An additional feature that supports feedback is known as polling. This feature allows the instructor to ask the class a multiple choice, Yes/No or True/False question. Optionally, the instructor can give students the ability to select "don't

know” as a valid answer. Because the poll is anonymous, students may feel more willing to admit to that they do not understand the content. When students vote by a show of hands in a traditional classroom, students may be likely to vote for a particular answer just because they see others doing so. With anonymous polling, students do not see each-other’s answers until the instructor decides to post them. After all students respond to the poll, it is easy to have DyKnow generate a bar graph or pie chart reflecting student answers. This graph can be displayed to the entire class. The polling feature allows the instructor to quickly gauge the level of understanding of the class as a whole, and help the students judge their own level of understanding. After a poll, the instructor may adjust the level of discussion to meet the needs of the class.

3.2 Students’ Reaction to the DyKnow Environment

A survey of 81 students at a small liberal arts college who have collectively taken 431 courses using DyKnow Vision indicated that students respond favorably to instructors’ use of DyKnow Vision for providing interactive exercises and feedback (Berque, 2005). Sixty-five percent of respondents believe that DyKnow Vision’s ability to provide feedback on quizzes electronically has moderate or significant value. Ninety-two percent of students place moderate or significant value on “doing in-class exercises to practice with content”. Many students state that they appreciate the ability to do in-class exercises in DyKnow. One stated “DyKnow is great for in-class exercises. I have gotten so much from the prepared slides with questions/problems for students to complete and submit”.

Students also appear to value the input from both instructors and fellow students during in-class exercises. Eighty-one percent of respondents indicate that they place moderate or significant value on “seeing how my peers have solved problems during class”. One stated “I like the fact that students can submit answers to class problems. This type of participation allows for students to see different solutions because there is frequently more than one way to solve a problem.”

Overall, 95% of students believe that DyKnow has moderate or significant value in “enhancing [their] understanding of material and concepts as they are presented during class”.

3.3 Teachers’ use of DyKnow Features to Provide Feedback

A recent survey of 10 instructors using DyKnow in Computer Science and Economics classrooms showed that instructors frequently make use of DyKnow features that can support effective feedback (Berque, 2005). Collectively these instructors have taught 90 courses with the DyKnow system, and their responses indicate that they are quite enthusiastic about using the software to provide feedback that promotes learning.

All ten instructors appreciated the ability to collect student work without disrupting the classroom and provide timely feedback. Seven out of ten survey respondents

use DyKnow to grade and return student work, and six out of ten indicated that they place moderate or significant value on the ability to provide feedback on quizzes through DyKnow. According to one instructor surveyed, "I love the play-by-play and electronic grading aspects." Teachers can find creative ways to provide feedback using DyKnow. For example, some teachers create responses for common errors and paste them in student work where appropriate. This allows teachers to spend the time to create detailed feedback that can be given to as many students as necessary without taking up class time.

In some circumstances, the replay feature appears to give instructors particularly valuable insight into the student thought-process. For example, Economics professors use the replay feature on student work to see how students have created complex graphs, and encourage students to do the same with their own class notes. Three out of four economics professors surveyed place significant value on their ability to replay material stroke by stroke, and all four professors placed significant value on the ability to allow students to replay their notes stroke by stroke.

Polling can also be used to quickly gauge the level of understanding in the class. After a poll, the instructor may decide to provide further instruction, or provide for other learning opportunities such as group work. Five out of ten instructors sometimes or frequently "use multiple-choice polling to get anonymous feedback from students", while another three use this feature on rare occasions.

With DyKnow, instructors can also receive quick feedback from students through the use of interactive exercises and the polling feature. According to one instructor, "It is great at allowing me to make sure students 'get' a concept in class by doing quick in-class exercises." If it becomes clear that the class understands a concept, the instructor can go on. If many students appear to be misunderstanding key concepts, the instructor can add more material on the fly. This immediate feedback will also help the instructor plan better for future years. All ten instructors placed moderate or significant value in the ability to see how students have solved problems during class. According to one instructor "DyKnow energized me and was an impetus for me to tweak my courses and teaching approaches during the semester."

Teachers in an elementary school setting also notice that collecting work and giving feedback through DyKnow can be a good way to engage students and address issues early. According to Joan, a sixth grade instructor cited in a case study of North Daviess Elementary School (Rockman, 2005): With DyKnow Vision, students are eager to submit work for the teacher to review... DyKnow Vision also gives [Joan] more immediate feedback on students' grasp of concepts during an instructional period. Rather than waiting until the end of a lesson to assess students' understanding, she can build assessment into various stages of the lesson. Knowing sooner what students do not understand allows Joan to modify her instruction on-the-fly and thereby help ensure concept mastery.

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Laura, a fourth grade teacher in North Daviess, has found that using DyKnow for informal assessments and practice activities during class has encouraged participation. Instead of raising hands to offer answers, which may be intimidating for some students, Laura has her students submit their answers anonymously. This can allow her to get responses from all of the children in the class. In turn this helps her to determine whether the material has been comprehended by the majority of the class. It also allows her to highlight the work of some normally lower-performing students, helping them to build self-confidence. Best of all, instead of being intimidated or bored by these practice activities, “students see these informal polls as ‘games’ and are extremely interested in seeing the results” (Rockman, 2005).

Laura often combines opportunities for practice and feedback with active learning techniques, giving students an opportunity to receive feedback from their peers and reduce judgment bias regarding their own work. For example, during a Social Studies unit she may ask students to fill in several open-ended questions provided on DyKnow panels. Laura uses DyKnow to display a timer on the screen in the front of the room. When the time is up, all students submit their panels, and Laura displays a different student’s response for each question. She then asks the class to clap to indicate whether they agree or disagree with the student response. The class then engages in an interactive discussion about the subject material (Rockman, 2005).

4 Conclusion

In this paper, we have seen that feedback can be a valuable tool for supporting student learning when used properly. Research stresses the need to provide timely and appropriate feedback that can help a student improve study skills as well as get a better understanding of specific material. A tool like DyKnow Vision, which allows instructors to provide immediate feedback in a variety of ways, may be used to further enhance instructor’s ability to provide useful and timely feedback to students.

5 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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