

Utilizing DyKnow Software and Pen-Based, Wireless Computing in Teaching Introductory Modern Physics

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Abstract - In the fall semester of 2005, in order to capitalize fully on opportunities provided by pen-based computing and wireless technology, Fort Hays State University began to implement Tablet PCs and DyKnow software package in teaching. DyKnow software is designed to promote engaged and dynamic instruction and to facilitate classroom communication in all directions.

This paper reports on modalities and results of using DyKnow software in a calculus-based, sophomore-level modern physics course for physics majors. The study was conducted in fall semester of 2006. DyKnow was used to facilitate note taking, to maximize classroom interactions in primarily lecture setting, and to enable synchronous collaborative problem solving. The software also features several effective, nontraditional venues for student feedback and formative assessment which were regularly used during the semester.

The effectiveness of the approach was measured through test score comparisons, students' end of the semester teacher/course evaluations and through multiple surveys eliciting students' input and feedback related to the instructional value of the utilized software and hardware.

I. INTRODUCTION

In the fall of 2005, Fort Hays State University (FHSU) initiated a campus-wide mobile computing program, with the purpose of promoting and investigating effective ways of using Tablet PCs (among other devices) in teaching and learning. As part of the initiative, FHSU employed DyKnow Vision software, designed to foster interactive classroom instruction. DyKnow Vision comes highly praised as a promising instructional tool for all educational levels, from the pre-primary [1] to the tertiary [2]. A growing number of studies indicate beneficial effects of the software use on student learning and attitudes. This has been the case in a variety of fields, ranging from computer science [3] and mathematics [4] to special education [5], and Japanese language study [6]. The benefits include high levels of student engagement, better learning and retention of concepts, higher rates of homework completion, and fewer absences [7]. The list of DyKnow features that work toward making instruction more dynamic is extensive. Below is a short overview of those features most relevant for presenting the results of the study.

The software operates with interactive whiteboards (panels), which teacher can prepare in advance, create during the class, or use an optimal combination of those approaches. The teacher-generated content is transmitted in real time to individual students' computers and

displayed on their screens. This way students can make their annotations on top of and in addition to the teacher's content without need to copy any of it. The content can also be produced collaboratively by a group of students with each student annotating the group's slide from his/her individual computer. Changes that any student makes reflect instantly on screens of the group members. This opens variety of options for engaging students through group activities, collaborative investigations, and problem solving. While students work (either individually or in groups) the teacher can monitor their work from his or her screen and mediate as needed. DyKnow also provides multiple channels of obtaining students' feedback (such as display of the status of students' understanding or chat option) and variety of ways for probing students' understanding in real time (such as the pooling tool, equivalent to classroom response system).

DyKnow notebooks, consisting of panels created and personalized in ways described above, are individually saved and can be used for later study. While reviewing, students can playback slides so annotations appear in the order in which they were written. Created notebooks the teacher can use to help absent students and as an active template for next year's teaching. The software works optimally with Tablet PCs but can be used with laptops and desktops as well.

II. RESEARCH QUESTIONS AND METHODOLOGY

This study investigated effectiveness of DyKnow software in teaching of a sophomore level calculus-based modern physics course. The course is a 3rd semester core course for physics majors covering relativity, atomic and nuclear physics. The study was conducted in fall semester of 2006 (F06) at Fort Hays State University, one of the six public institutions in the state of Kansas, USA.

During the F06 semester, data was collected through tests and surveys in order to answer the following research questions as pertaining to this type of course:

1. Given the choice of utilizing different levels of technology involvement in instruction, what is the students' preference in terms of the:
 - a. instruction/presentation mode
 - b. problem-solving mode?
2. What are the positive and negative aspects of using tablet PCs and DyKnow software as perceived by students – users?

3. Does usage of tablet PCs combined with DyKnow software make impact on:
 - a. students test scores
 - b. instructor's evaluation scores?

Students' preferences and attitudes related to DyKnow software and tablet PCs were elicited during and at the end of the F06 through two different surveys. To address the question related to test scores, students' test results in F06 were compared to results in preceding semester went to course was taught i.e. fall semester of 2005 (F05). Similarly, instructor evaluations results were compared for these two semesters. F05 and F06 were the only two semesters in which the author taught this course at FHSU (or elsewhere).

Course instruction during F05 involved usage of tablet PC on the instructor's side (while students did not have their tablet PCs and DyKnow software was not used). In that setting, the electronic pen was used to annotate in advanced prepared PowerPoint slides, to write derivations and to solve problems. Annotations and derivations done during the class were projected on the classroom screen rather than written on the chalkboard. The advantage of this approach was the ability to post the material online right after the class so that students would have access to the teacher's notes. This reduced the need for students to copy the teacher's notes onto the paper. In F05, the electronic pen was combined with the traditional chalkboard for occasional digressions and for solving longer problems which could not fit the screen and for which it was important to have them visible in their entirety.

During the next offering of the course in fall semester of 2006 (F06) the physics department at FHSU had a set of 15 tablet PCs available for classroom usage. With this set, in F06, each student enrolled in the course had his or her individual tablet PC to use during class time. Students were also allowed to check tablet PCs out when classes were not in session. In addition to tablet PCs, throughout the whole F06 semester, the instructor regularly used DyKnow software in teaching the course.

There were 13 students enrolled in the course in F05, and 11 in F06. Out of the eleven F06 students, one was not attending classes on campus but was being supported at a distance. This off-campus student was a high school chemistry teacher seeking physics endorsement and taking the course for that purpose. Because of his special situation, he did not take surveys, and his test results are included in statistical data presented in this paper. However, DyKnow software played an important role in supporting his learning at a distance. Because of the DyKnow implementation, all the class activities (both the instructor's and those of students) were continuously displayed on the instructor's screen during class time, and this enabled simple and meaningful audiovisual recording of all classes using a screen capturing program called Camtasia. These recordings had been saved in flash format to minimize the size (up to 20 MB), and were posted online after the class. The single off-campus student as well as on-campus students who occasionally had to miss the class appreciated this feature.

III. RESULTS AND ANALYSIS

Results of the study are presented and analyzed below by following the order of the listed research questions.

Instruction and problem-solving preferences

In F06, after three months of a four-month semester, after students had been exposed to a variety of instructional and problem-solving modes, a survey was administered requesting input regarding their preferred style(s). The instructor announced to students his commitment to adopt and utilize the most preferred mode(s) until the end of the semester. The primary purpose of this survey was to elicit students' preferences for learning and not necessarily to elicit their opinion on DyKnow software or tablet PCs. Their opinions related to those technologies surveyed at the end of the semester.

To obtain their instructional presentation preference was elicited so that students were offered different broad choices and they rated each choice separately on a scale of 1-10, with 10 representing the best alignment with their preference. The choices offered in the survey question were described as follows (with notes added in this paper for contextual clarifications):

“Chalkboard” - Instructor writes on chalkboard, you take notes on paper. (Note: This choice refers to the traditional presentation mode, which does not involve any technology)

“Blackboard” - Instructor writes on screen, you take notes on paper, but at the end instructor posts his notes on Blackboard. (Note: Blackboard refers to The Blackboard Academic Suite™ - an online course management system used throughout the course. This choice represents the presentation mode utilized in F05 when only instructor had a tablet PC, and students did not).

“In class writing with DyKnow”- Instructor writes derivations on DyKnow slides so writing appears also on your screen - as it is written. (Note: This mode fully utilizes opportunities of both DyKnow software and tablet PCs. Students see the relations derived step by step, and they can take notes in addition to the teacher's notes which are automatically transmitted to their screens).

“Pre-prepared slides with DyKnow” - For the most part instructor pre-prepares the slide content and sends a whole slide at one time and follows up with explanation. (Note: this mode differs from the previous one in that derivation is not done in the class. Rather, it is prepared in advance and only explained in the class.). Table I shows results obtained for this question. The survey was taken by all students (N=10).

The results in Table I demonstrate students' preference for DyKnow facilitated instruction, as opposed to “Chalkboard” mode, or even “Blackboard” mode, in which the teacher's notes are available to students after the class, but not transferred to their computers in real-time. In addition, the table shows that students prefer that they see derivations written in the class, rather than prepared in advance and then explained. Preparing derivations in advance had, in the instructor's view, the advantage of saving the class time for other activities and could have been used, for example, for brief overview of less critical derivations.

TABLE I
STUDENTS' PREFERENCES RELATED TO
INSTRUCTIONAL MODES, EACH RATED ON SCALE 1-10

Rate instruction modes individually (Scale 1-10):	Average (Scale 1-10)	SD	Mode	Median	Rank per Average (out of 4)	Model Facilitated by DyKnow
1. "Chalkboard"	4.6	2.9	1	5.5	3 / 4	No
2. "The Blackboard"	4.6	3.0	1	5.5	3 / 4	No
3. In class writing with DyKnow	8	1.5	7	8	1	Yes
4. Pre-prepared slides with DyKnow	6.9	2.9	9	7.5	2	Yes

Six out of ten students wrote a comment as a follow-up on numerical input related to their ratings. These comments (for this and other open-ended questions) are presented below so that representative statement is quoted followed by the number of students whose comment falls into same category:

- "[...] for the most part I would like to see the slides written out in class. It's as if you would be using DyKnow as the chalkboard. It just makes it easier to "see" how ideas are developed, when they are actually written out step-by-step in class [...]" (N=5)
- "I like it when you are actually moving during class [...] pointing at something on the screen etc." (N=2)

In this mid-semester survey, students also rated their preferences for problem solving (again on the scale from 1 to 10 with the score 10 representing the best alignment). The offered choices as well as results are shown in the Table II.

Two modes which surfaced as students' top preferences for problem-solving were both DyKnow-based. These choices are collaborative problem-solving in student groups (choice 6) and with the whole class solving problems together with the instructor on the same slide (choice 7). One of the two choices that closely follow in rank is individual problem-solving, which was also done in DyKnow mode throughout the course. The advantage of using DyKnow for individual problem-solving (as opposed to individual solving on paper) is the teacher's ability to share and/or discuss a particular student's solution with the whole class as well as monitor their individual progress as they work on the problem.

The problem-solving mode, in which the instructor solves problems on his/her own and posts the solution on the Blackboard (choice 2) also came out highly rated. Note that this was not the case with the equivalent instructional mode in the first survey question. Not being sure how to interpret this result, the instructor informally followed up and found out that some students particularly liked when

an additional (not shown in class) set of solved problems was posted by the instructor online for students to review.

This set was more neatly written and better organized than typical problems solved during class time. According to results, students also didn't mind having the instructor solve problems alone in real-time, using DyKnow (choice 3). The chalkboard mode (choice 1) did not come highly appraised. But the least popular of all choices was a DyKnow-based mode, in which the instructor solves the problem in advance and sends the solution as a ready-made slide to class and then following up with an explanation (choice 4).

Thus, while most of the DyKnow-based instructional and problem-solving modes were students' top choices, certain ways of using DyKnow came out as the least appreciated modes, with ratings lower than those of the traditional, "technology-free" instructional mode. This seems to be another example showing that technology itself is not an educational panacea; however, particular ways of using it may secure significant progress. Along those lines, it is informative to note that, while pre-prepared slides with solved problems were students' least appreciated choice, the equivalent instructional mode received above average ratings.

TABLE II
STUDENTS' PREFERENCES RELATED TO PROBLEM-SOLVING MODES, EACH RATED ON SCALE 1-10

Rate problem-solving modes individually (Scale 1-10): Problems are solved by ...	Average (Scale 1-10)	SD	Mode	Median	Rank per Average (out of 7)	Model Facilitated by DyKnow
1. Instructor on the chalkboard	4.5	3.3	1	5	6	No
2. Instructor on screen and posts them later on Blackboard	6.5	3.3	1	7.5	3 / 4	No
3. Instructor on DyKnow so they appear on students slides as solved	5.9	3.3	1	6.5	5	Yes
4. Instructor in advance, sends solution through DyKnow and explains the solution	3.5	1.9	3	3	7	Yes
5. Students individually	6.5	3.3	10	6.5	3 / 4	Yes
6. Students collaboratively, in groups	6.6	2.3	6	6.5	1 / 2	Yes
7. Instructor and students by working at the same time on the same problem and writing on the same slide.	6.6	1.8	8	6.5	1 / 2	Yes

After giving their ratings, students were given an option to follow up with a comment related to their problem-solving preference. Below are received comments:

- "...Ideally I would like to have you give us about 1 minute to individually think about how we would go about solving the problem before you solve it on DyKnow (that is writing out the solution in class). ... But it is also nice to have you mix it up every once in a while. ..." (N=1)
- "I think it would be best if we all worked on the same problem, but individually. Then once everyone is done, or we've had enough time to think it out and work on it, we could go through it as a class, as you work it out on DyKnow." (N=1)
- "I enjoy working the problems myself or in groups" (N=1)

Based on results of this first survey, DyKnow was used in the course by the end of the semester in a variety of modes with students' top choices being utilized most frequently.

Opinions about DyKnow

In order to elicit students' opinions and attitudes about DyKnow software, another survey was administered at the end of the semester. This survey was answered by nine out of ten students and results are presented in the Table III. The results in Table III are given in absolute numbers.

TABLE III
STUDENTS' OPINIONS AND ATTITUDES ABOUT
DYKNOW SOFTWARE

Category	Statement: Using DyKnow ...	Strongly Agree	Agree	Disagree	Strongly Disagree	N
General	was enjoyable	3	5	1	0	9
	Made learning more fun	2	5	1	1	9
	Was very challenging	0	1	7	1	9
	was very frustrating	1	2	4	2	9
	was a waste of time	0	0	5	4	9
Cognition	helped me take better set of notes	0	6	3	0	9
	facilitated my learning	2	6	1	0	9
	enhanced my understanding of the course material	1	4	2	1	8
Communication	enhanced my interaction with classmates	2	6	1	0	9
	enhanced my interaction with the instructor	2	5	2	0	9
Motivation	I was more attentive when DyKnow was used	1	3	4	1	9
	I was more motivated when DyKnow was used	1	2	5	1	9

The results above show that students' overall attitudes toward the DyKnow software were highly favorable. Eight out of nine students stated they enjoyed using the software. Also, no student thought she or he wasted time using DyKnow. At the same time, the level of frustration with the software was pretty low (33.3%), and according to the comments in the follow up question, this was primarily caused by technical difficulties with wireless network rather than the software itself. Most students thought DyKnow helped them take better set of notes (66.6%), and it facilitated their learning (88.8%). According to the table, for two students DyKnow facilitated learning (studying), but that was not accompanied by enhanced understanding of the course material. This seeming discrepancy could be explained by the relatively difficult nature of the course. In a similar way in which well written but highly technical books might not always get the message across for a novice reader, difficult material might present a similar kind of obstacle in this case.

DyKnow enhanced students' interaction with both the instructor (77.7%) and their peers (88.8%). Further, 44.4% of students were more attentive when DyKnow was used, and 33.3% felt more motivated. Although percentages related to increased motivation and attentiveness were not as high as others, they can be considered favorable, given that DyKnow did not decrease anyone's motivation or attention, and according to the preciously mentioned ratings in Table III, that was not the case.

In the same survey, students had an opportunity to give an open-ended input to substantiate their ratings. Below are follow-up questions and students answers to them:

1. What have been the biggest advantages, if any, of using DyKnow? Six out of nine students made written comment, some of them mentioning more than one feature.
 - "I could follow along better because I didn't have to worry about scribbling notes down." (N=4),
 - "The instructor can check to see if students are understanding by having us submit our slides." (N=1),
 - "Interactivity" (N=1),
 - "I enjoyed being able to see the problems being worked out on the tablet screen" (N=1).
2. What have been the biggest disadvantages, if any, of using DyKnow? The same six out of nine students made written comments on this question.
 - "The only disadvantage was if the network was down at the time of class." (N=3),
 - "lack of ability to take notes on paper" (N=1),
 - "short amount of class time" (N=1),
 - "When the notes are pre-written by the professor... it can be rather boring and very difficult to understand" (N=1),
 - "I couldn't have the notes at home because DyKnow was not compatible with my Macintosh computer" (N=1).

3. What problems did you have when using DyKnow?

Five out of nine students made written comment (sub set of previous six):

- “None” (N=2),
- “Mainly when the slides were pre-written out” (N=1),
- “Occasional slow loading of slides” (N=1)
- “DyKnow freezing and not being able to save the current session” (N=1).

At the end of this survey, students were requested to rate their overall experience related to the use of DyKnow software and Tablet PCs, and give their recommendation for future on-campus use of this software and hardware. Tables 4 and 5 show results related to these questions.

TABLE IV
STUDENTS’ OVERALL EXPERIENCE RELATED TO USAGE OF DYKNOW SOFTWARE AND TABLET PCS

My overall experience related to the usage of the...	Positive		Neutral	Negative	
	Very Positive	Positive		Negative	Very Negative
DyKnow software was	1	5	2	1	0
Tablet PC (as opposed to laptop or stationary computer) was	1	6	1	0	0

Having an option to make a neutral choice, six students rated positively their overall experience with DyKnow (as opposed to one negative rating). At the same time seven students positively rated experience with Tablet PCs, with one neutral rating and no negative ones.

Neither DyKnow software nor tablet PCs received any “no” answers with respect to recommendations for future implementation in this or other courses. They come equally recommended for other courses (seven recommendations and two neutrals) while tablet PCs come even more highly recommended in this particular course (eight recommendations for tablet PCs vs. five for DyKnow) with rest of the answers neutral.

TABLE V
STUDENTS’ RECOMMENDATIONS RELATED TO FUTURE ON CAMPUS USAGE OF DYKNOW SOFTWARE AND TABLET PCS

In future I would recommend that...	Definitely Yes		Neutral	No	Definitely No
	Yes	Yes			
DyKnow keeps being used in THIS course	1	4	4	0	0
DyKnow is implemented in OTHER on-campus courses as well	1	6	2	0	0
Tablet PCs keep being used in THIS course	2	6	1	0	0
Tablet PCs keep being used in OTHER on-campus courses	1	6	2	0	0

Test results

The content covered in the course during F05 and F06 semesters was the same, and the course was taught using the same textbook in both semesters. Three tests were administered in each semester. The problems were different in the subsequent semester but had the same level of difficulty. In both semesters, one test was repeated (the first test in F05 and the second one in F06) to encourage further learning and improved understanding of important concepts. Individually, the average score for two out of three respective tests was higher in F06 than in F05 (for both initial and repeated test). However, not all respective tests covered the same chapters. For this reason, in order to make a comparison between semesters, each of the test scores were normalized to hundred percent and individual average results were compared.

Both average test results were substantially better (9.39% for initial and 6.75% for repeated results) but because of the small samples, this difference did not make the result statistically significant at 0.05 level (see Table VI). The statistical significance was probed using independent samples t-Test, assuming equal variances (with equality of variances established with Levene’s test).

The above analysis of test results did not include the off-campus student. His scores would have increased the mentioned difference because the average score for all of his tests was 93.73%, and each of his individual test scores was better than average of the rest of the class in F06. Under supervision, he took the same tests as other students, but he was not learning the material the same way as on-campus students, so including his scores with others would not be justifiable. However, it is important to note that the combination of DyKnow software, tablet PC and Camtasia software described in the methodology section was a crucial component in his successful learning. Below is his spontaneous follow up comment, written at the end of the e-mail in which he sent a homework submission to the instructor: “Your Blackboard materials, Camtasia recordings and text book helped me alot. Very many special thanks for sending me the Camtasia recordings. Those recordings helped me alot in understanding the concepts (as if I am in the real classroom). [...] Thanks a billion!”

TABLE VI
COMPARISON OF TEST RESULTS IN F05 AND F06 SEMESTERS

	F05 (N=13)		F06 (N=10)		P(T<=t) one-tail
	Average (%)	SD (%)	Average (%)	SD (%)	
Initial test results	71.31	13.04	80.70	16.51	0.1035
Repeated test results	75.78	10.54	82.53	15.92	0.1635

Teacher Evaluation scores

The teacher evaluation instrument (TEVAL) used at FHSU was developed at Kansas State University and it is administered in all courses at the end of every semester. The comparison of TEVAL results in F05 and F06 in this course shows that students' evaluations improved in all three major categories (Instructional styles, facilitating learning, and Overall evaluation). On average, students' initial interest in the class was less strong in F06, but at the same time students put more effort into learning. However, similarly as with the test scores, although TEVAL results were improved when DyKnow and tablet PCs were used, the difference in results was not statistically significant. The greatest difference in any of the individual TEVAL categories was found in the average scores pertaining to perceived amount learned (category 4c in the Table VII) with p-value of 0.0588 and in favor of the F06 semester.

TABLE VII
TEACHER EVALUATION RESULTS

	Average F05 (Scale 1-5)	Average F06 (Scale 1-5)	F06 > F05	P(T<=t) one- tail
1. Relevant Student Attributes	3.68	3.78	Yes	0.3717
1a. Strong interest in class	3.73	3.56	No	0.3619
1b. Worked hard to learn	3.64	4.00	Yes	0.1522
2. Instructional Styles	4.16	4.19	Yes	0.4169
2a. Made objectives clear	4.00	3.89	No	0.3645
2b. Well prepared	4.27	4.22	No	0.4401
2c. Interested in teaching	4.18	4.33	Yes	0.4291
2d. Available for help	4.18	4.33	Yes	0.2672
3. Facilitating Learning	3.76	3.84	Yes	0.3199
3a. Explained clearly	3.45	3.44	No	0.4896
3b. Stimulated thinking	3.91	4.22	Yes	0.1865
3c. Made helpful comments	3.45	4.00	Yes	0.0667
3d. Graded equitably	4.18	4.22	Yes	0.4506
3e. Sensed confusion	3.82	3.33	No	0.1451
4. Overall Evaluation	3.70	3.93	Yes	0.0998
4a. Teacher effectiveness	4.00	3.89	No	0.3471
4b. Increased desire to learn	3.45	3.78	Yes	0.1770
4c. Amount learned	3.64	4.11	Yes	0.0588

It should be noted it is possible that improved test scores and improved TEVAL scores are not entirely attributable to technology implementation but could be partially results of the fact that the instructor was teaching the course the second time around and had more experience doing it then the first time.

IV. CONCLUSION

This study investigated effectiveness of DyKnow software and tablet PCs in teaching sophomore level modern physics course at Fort Hays State University. The results showed that students on average preferred instructional and problem-solving modes which utilize

both DyKnow software and tablet PCs when compared to less technologically involved choices. Among different modalities of using DyKnow, dynamic ones (featuring materials developed in class) were still much higher rated than those in which slides are prepared in advance. This difference was especially clear in students' problem-solving preferences. Majority of students reported they enjoyed using DyKnow. It enabled them to take a better set of notes, to learn better and it improved their interaction with both instructor and their peers. Negative aspects of DyKnow usage that were mentioned include occasional network slowness and downtime, modes of DyKnow usage when content is prewritten rather than developed in class and incompatibility with Mac platform.

Average test results when DyKnow was used (F06) were higher than in preceding semester (F05) when DyKnow was not used. However, the difference was not statistically significant. Similarly, teacher's evaluation scores improved in F06 but the difference was not statistically significant. That study finally indicated strong potential of DyKnow software in combination with tablet PCs and Camtasia software for distance course delivery. Further study is suggested with different populations, larger classes and different courses.

REFERENCES

- [1] L. Lindroth, "Blue Ribbon Reviews," *Teaching Pre K - 8*, vol. 36, pp. 25, 2006.
- [2] J. Roland, "Reviews - DyKnow Vision and Monitor," *The ISTE (International Society for Technology in Education) journal of educational technology practice and policy*, vol. 33, pp. 38, 2005.
- [3] D. Berque, T. Bonebright, and M. Whitesell, "Using Pen-Based Computers Across the Computer Science Curriculum," presented at 35th SIGCSE Technical Symposium on Computer Science Education, Norfolk, VA, 2004.
- [4] J. Hubbard, "Use of pen-based technology in calculus courses," in *The impact of Tablet PCs and pen-based technology on education: Vignettes, evaluations and future directions*, D. A. Berque, J. C. Prey, and R. H. Reed, Eds. West Lafayette, IN: Purdue University Press, 2006.
- [5] M. E. Exter and T. A. Ochoa, "Interactive Assistive Technology: A Preliminary Analysis of the Use of DyKnow Vision and Wacom Graphire3 4X5 USB Tablets in a Special Education Teacher Preparation Course," in *The impact of Tablet PCs and pen-based technology on education: Vignettes, evaluations and future directions*, D. A. Berque, J. C. Prey, and R. H. Reed, Eds. West Lafayette, IN: Purdue University Press, 2006.
- [6] R. Itoh, "Use of Handwriting Input in Writing Instruction for Japanese Language," in *The impact of Tablet PCs and pen-based technology on education: Vignettes, evaluations and future directions*, D. A. Berque, J. C. Prey, and R. H. Reed, Eds. West Lafayette, IN: Purdue University Press, 2006.
- [7] Rockman Et Al, "A case study of DyKnow Vision: Conversations and observations that demonstrate its educational potential," Retrieved Jan 20, 2007, from <http://www.dyknow.com/products/more/North%20Davies%20case%20study%20-%20FINAL.pdf>