IMPACT OF TABLET PCS AND DYKNOW SOFTWARE ON LEARNING GAINS IN INQUIRY-LEARNING ORIENTED COURSE

Zdeslav Hrepic[1], Kristin Miller[2]
Columbus State University[1], Fort Hays State University[2]
zhrepic@gmail.com[1], kwmiller@scatcat.fhsu.edu[2]

ABSTRACT

Tablet PCs and DyKnow software were utilized at Fort Hays State University in the teaching of an inquiry-based physical science course for elementary education majors since the summer semester of 2006. This course was originally developed in 2004 and 2005 through an NSF sponsored research effort. In this paper we compare learning gains obtained in this course during three semesters when pen-based computing technology was not utilized (Fall 04 - Fall 05) with gains obtained during three later semesters (Fall 07 - Fall 08) in which we utilized Tablet PCs and DyKnow software in teaching the course. We also report on students' attitudes toward DyKnow software and compare them with obtained learning gains.

1. PROBLEM STATEMENT AND CONTEXT

Tablet PCs and DyKnow software have been initially deployed at Fort Hays State University, a state supported university in Kansas, on a pilot basis in the summer of 2006 (U06). One of the pilot courses for this technology was a concept-level, inquiry oriented physical science course for preservice elementary teachers. It quickly became evident that this technology has potential to radically enhance interaction dynamics in the course. In several independent ways the technology facilitates collaborative data collection, exchange of findings and the follow-up discussions - all of which are critical for inquiry-based course.

The feedback obtained from students at the end of the U06 semester, when technology was first utilized, was exceptionally positive with respect to both tablet PC hardware and DyKnow software [3,4,6]. At the same time productive, investigations and discussions that were largely facilitated by the technology, advanced the level of covered content which at places reached level typical for an algebra-level course. We discussed those results extensively earlier [2,6].

Based on positive experiences and excellent feedback, the same technology was used in the following (F06 and S07) semesters in the physical science course and also in a modern physics course taught by the same instructor. All metrics used in evaluating the modern physics course showed favorable results for the technology [2,6]. Their test scores improved when compared to the earlier semester. Students' opinions about it were very positive and most students recommended continued usage. Also, instructor evaluations were more favorable in the semester when technology was used [2,6]. Similarly, in the physical science course in F06 and S07, students feedback related to the technology was also very favorable. However, the level of learning that was reached in those two semesters in the physical science course was clearly not as high as it was in the previous summer semester (U06) [3,4,6]. These results prompted us to further investigate what effect, if any, this technology has on student learning in this type of largely hands-on and discussion-oriented course.

2. SOLUTION EMPLOYED

This course was developed through an NSF funded research project [5]. For this reason student learning in the course was closely monitored between the fall of 2004 (F04) and the fall of 2005 (F05) - i.e. one year before the technology was deployed in it. The earlier study related to the course effectiveness provided the opportunity to extend the research and compare learning gains obtained in this course with and without the technology deployment. In order to capitalize on available ground data in F07 and following two semesters (S08 and F08) we deployed the same, externally developed [7] tests that were used in the course during the F04-F05 semesters.

3. EVALUATION

We earlier reported on preliminary results of this study based on the F07 and S08 results. [3] In this report we show final results that involve six semesters of course implementation - three without technology (F04-F05) and another three with technology (F07-F08). Learning gains in content knowledge were measured for each module through pre- and post-instruction tests. In all those semesters we used the same tests and they were graded using the same key, but originally by different graders in different semesters. Therefore while analyzing data for this report, in order to ensure maximum consistency in scoring open-ended answers, we re-graded all the tests in a way that the same person graded the same questions in all tests in all the semesters using a comprehensive grading key enhanced by consistently incorporating actual variations of student answers into it.

Hake [1] argues that a normalized gain is an accurate measure of the effectiveness (or non-effectiveness) of a particular presentation style. By definition; Normalized Gain = (post-test% - pre-test%) / (100% - pre-test%). Table 1 shows the results obtained for motion module and electricity module respectively and together. The statistical significance of differences were determined by t-tests (sig. level 0.05 two tailed) with equality of variances determined by F-test.

Table 1: Normalized Content Knowledge Gain Scores for Modules and Semesters

Module	Semesters	DyKnow used	N**	Pre-Test Score Mean (+/- SD)	Post-Test Score Mean (+/- SD)	Normalized gain Mean (+/- SD)
Motion & Electricity	F04,S05,F05	NO	103	38.8% (+/- 16.3%)	73.9% (+/- 13.1%)	56.8 (+/- 20.0)*
	F07,S08, F08	YES	80	37.8% (+/- 16.7%)	69.6% (+/- 18.3%)	51.5 (+/- 26.0)*
Motion	F04,S05,F05	NO	50	46.6% (+/- 14.7%)	78.6% (+/- 9.4%)	59.8 (+/- 15.14)*
	F07,S08, F08	YES	40	47.0% (+/- 16.7%)	69.0% (+/- 18.8%)	43.7 (+/- 27.3)*
Electricity	F04,S05,F05	NO	53	31.4% (+/- 14.3%)	69.5% (+/- 14.5%)	53.9 (+/- 23.3)*
	F07,S08, F08	YES	40	28.6% (+/- 10.6%)	70.2% (+/- 18.1%)	59.3 (+/- 22.4)*

*$p < 0.01$;
**N (Electricity) ≠ N (Motion) in respective semesters because of students who omitted to take the pre-test or dropped

Figure 1 (below) shows longitudinal variations in gain scores for the two modules combined. The learning gains for both of the modules were highly significant ($p << 0.01$) in each of the semesters, both individually per semester and cumulatively for semester groups. However, the comparison between the F07-F08 (Tablet PC/DyKnow) semesters and the F04-F05 semesters for cumulative results of both modules show lower gains for the F07-F08 (Tablet PC/DyKnow) semesters. This difference was not statistically significant ($p=0.135$) but the drop between F05 and F07 was highly significant ($p=0.0002$).

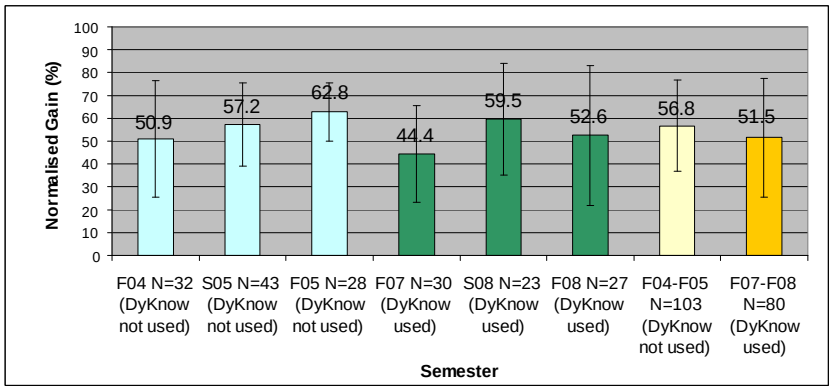


Figure 1: Normalized gains for electricity module and motion module combined per individual semesters and semester groups (F04-F05 vs. F07-F08 semesters).

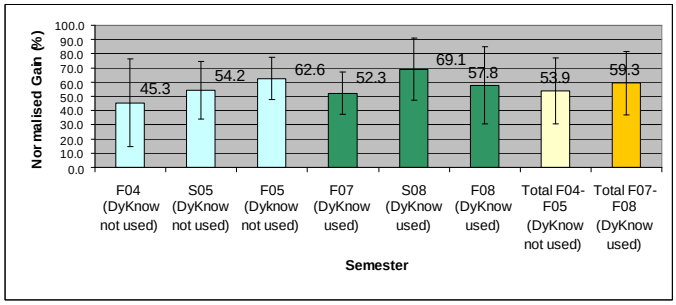
The same instructor taught the course each semester between F04 and F08. This increase of gains in the F04-F05 period (Figure 1) when technology was not used could be attributed to improvement of instructor's proficiency in teaching the course over time. This possible explanation is one of the reasons why the sharp drop in gain between the F05 and F07 semesters surprised the instructor. The other reason for the surprise was high knowledge level accomplished in U06 when the technology was first implemented [3,4,6] (tests used in that semester were different, and not comparable with tests given in other semesters analyzed here). Finally, the drop was surprising because of a consistently high level of student satisfaction with the Tablet PCs and the DyKnow software in all the semesters since U06 (including F07) [3,4,6].

Possible reasons for this drop may have included: (i) since U06, the paper textbook was not required. Instead, electronic reading resources were made available. (ii) since tablet PC implementation, students were taking electronic notes in two different places (by electronically inking MS Word worksheets and DyKnow slides). A few students who preferred taking notes on paper sometimes used all three of those media. (iii) In U06, homework load for students was reduced in comparison to previous academic year semesters. In an intense summer course this had no adverse affect on students' retention and scores but it could have had in later semesters,.

Based on these assumptions, in S08, the instructor made the following changes: (i) specifically laid out electronic reading sources for students as they pertained to different topics and tied HW questions to them. (ii) imported a greater portion of worksheets into DyKnow slides. (iii) increased the homework level, so assignments again became similar to those in F04-F05 period. These implemented changes resulted in clear increase of the learning gains. And the gain change between the F07 and the S08 semesters for the two modules combined was significant ($p=0.018$). At this point problem(s) seemed solved. So in F08 instructor implemented essentially more of the same strategies as in S08 semester: In addition to making electronic reading resources available, the textbook was required again. (In order to still capitalize on affordable resources, we adopted an earlier edition of the textbook available secondhand online for several cents.) We also further intensified level of HW activities and shifted class time allocation toward harder concepts.

However, gain in F08 dropped when compared to S08, to a level midway between F07 and S08. To investigate this further, we analyzed gains separately for the electricity module and for the motion module. This analysis revealed opposite trends for these two content areas (Figure 2).

Electricity Module



Motion Module

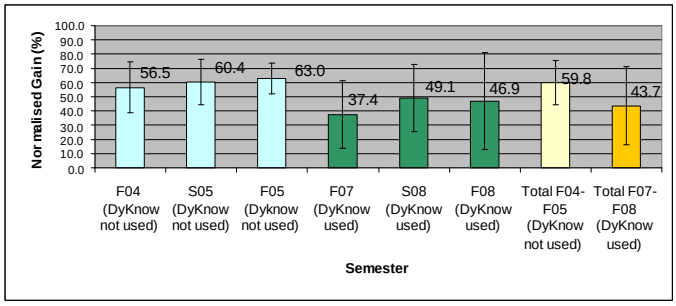


Figure 2: Normalized gains for electricity module (above) and for motion module (below) per individual semesters and semester groups (F04-F05 vs. F07-F08 semesters).

Gain for electricity module (Figure 2) is higher for F07-F08 (Tablet PC/DyKnow) semesters than for F04-F05 semesters. This difference however is not statistically significant ($p = 0.27$). On the other hand, the gain for the motion module (Figure 3) is lower for the F07-F08 (Tablet PC/DyKnow) semesters (than F04-F05) and this difference is highly significant ($p = 0.0008$).

Table 1: Normalized Content Knowledge Gain Scores for Modules per Semester

Semester	TPC & DK used	Motion Module					Electricity Module				
			Pre-Test Score (%)		Post-Test Score (%)			Pre-Test Score (%)		Post-Test Score (%)	
		N	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD
F04	NO	16	47.4	15.5	77.6	8.9	16	31.1	18.6	65.3	16.5
S05	NO	21	46.7	14.5	78.5	10.5	22	31.2	11.5	68.8	14.7
F05	NO	13	45.5	15.1	79.9	8.6	15	32.1	13.7	74.9	10.8
F07	YES	16	42.9	14.8	62.5	19.6	14	29.0	11.8	66.0	12.2
S08	YES	11	43.8	18.6	70.5	17.3	12	30.7	7.7	77.6	17.5
F08	YES	13	54.7	15.8	75.7	17.6	14	26.5	11.8	68.1	22.2

The drop between F05-F07 semesters was large for both modules but such was also the increase between F07 and S07. However, for the electricity module the initial drop was not statistically significant ($p=0.072$) while the subsequent increase was ($p=0.029$). Alternatively, for the motion module, the drop was highly significant ($p=0.0008$) and the increase was not ($p=0.218$). Although interesting, these results do not shed much light on the reasons for these differences. Nevertheless, a look to absolute values of pre-test and post-test scores (Table 1) was informative. The average post-test score of 75.7% obtained for motion module in F08 is highest among the three semesters when technology was used and it is still lower than scores obtained

between F04 and F05 (77.6% - 79.9%). However, low gain obtained for motion module in F08 is much more the consequence of the high pre-test score (54.7%, which is by far highest of all semesters) than by the post-test score. This is in contrast to the S07 semester when low gain for the motion module was caused by the low (lowest of all) post-test scores.
The dynamics of absolute post-test scores obtained for motion module between F07 and F08 semesters reveals an encouraging trend (from 62.5% to 70.5% and finally to 75.7%). This means that the changes that were made between the F07 and S08 semesters and later do make consistent positive difference in terms of student learning. At the same time, there are obviously other factors that play important roles in determining how effectively this technology is deployed in teaching, and these factors are not clearly identifiable from our research. Therefore in order to optimally capitalize on many outstanding benefits of this technology [3,4,6], further investigation of (especially unfavorable) unknowns in its implementation is necessary. This study did not show cumulative beneficial effect of this technology on gains in student learning. However, overall non-significant difference in learning gains, positive learning gain in electricity module and encouraging trend in post-test results for motion module all show that damage control is well in check while we continue capitalizing on benefits of this technology and optimizing its usage.

4. ACKNOWLEGEMENTS

This work was supported in part by NSF grants DUE-0311042 and DUE-0088818.

REFERENCES

[1] Hake, R.R., Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses., *Am. J. Phys*, 66 (1997) 64-74.

[2] Hrepic, Z., Utilizing DyKnow Software and Pen-Based, Wireless Computing in Teaching Introductory Modern Physics. In M. Čičin-Šain, I. Turčić and I. Sluganović (Eds.), *Proceedings of 30th Jubilee International Convention MIPRO, Conference On Computers In Education (2007), Vol. IV*, MIPRO, Opatija, Croatia, 2007, pp. 32-37.

[3] Hrepic, Z., Deploying Tablet PCs and DyKnow software in teaching inquiry-based physical science course. In D.A. Berque and J.C. Prey (Eds.), *The impact of Tablet PCs and pen-based technology on education: Vignettes, evaluations and future directions*, Purdue University Press, West Lafayette, IN, 2008, pp. 55-62.

[4] Hrepic, Z., Exploring the Role of Pen-Based Computing in Advancing Knowledge Society. In J. Langer, N. Alfirević and J. Pavičić (Eds.), *Proceedings from the international symposium "Alpe-Adria: Knowledge Region" (2007)*, Peter Lang, Frankfurt am Main, Germany, 2008.

[5] Hrepic, Z., Adams, P., Zeller, J., Talbott, N., Taggart, G. and Young, L., Developing an Inquiry-Based Physical Science Course For Preservice Elementary Teachers. In P. Heron, L. McCollough and J. Marx (Eds.), *Proceedings of 2005 Physics Education Research Conference, Vol. 818*, AIP Conf. Proceedings, Salt Lake City, Utah, 2005, pp. 121-124.

[6] Hrepic, Z., Rebello, N.S. and Zollman, D.A., Remedying Shortcomings of Lecture-Based Physics Instruction Through Pen-Based, Wireless Computing And DyKnow Software. In N.H. Salas and D.D. Peyton (Eds.), *Reading: Assessment, Comprehension and Teaching*, Nova Science Publishers, In press, 2009, pp. 97-129.

[7] Louisiana State University, Operation Primary Physical Science Homepage. *Vol. 2005*, 2005.