RUNNING HEAD: Beginnings to New Horizons

Beginnings to New Horizons

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Abstract

Fort Hays State University became part of the NASA-NOVA network in 1997 with its effort *A Model of Integrated Science and Mathematics Instruction for Preservice K-9 Teachers*. This work was followed-up with another NASA-NOVA effort in 1999, *Implementation and Integration of Inquiry-Based Science and Mathematics Learning for the Preparation of K-12 Teachers*. These original efforts led to the modification of five courses – two in physics, one in mathematics, one in education, and one in chemistry. While the specific course adaptations done fifteen years ago have been replaced or modified as the original faculty have retired or moved on to other positions, the impact of this effort is still present on the campus with the remaining faculty team and at other institutions for the faculty that have left Fort Hays State University. The panel session will examine how these initial efforts were used to engage faculty members in improving undergraduate education beyond the original NASA-NOVA team in improving undergraduate education, serve as a hot bed for collaboration and course development that led to two NSF grants, changes in faculty teaching and assessment styles, publications related to our work, continuing development of new courses (four at present), and improvement in teaching undergraduate science teaching and undergraduate research at Fort Hays State University (KS) and Columbus University (GA).

The Beginnings: FHSU NOVA Involvement

NOVA I

In 1997 FHSU received a grant from the National Aeronautics and Space Administration through the NASA Opportunities for Visionary Academics (NOVA) Project. NOVA was created to develop and disseminate a national framework for enhancing science, mathematics and technology literacy for preservice teachers in the 21st century. Fort Hays State University (FHSU) was provided an opportunity to improve mathematics and science content knowledge of elementary preservice teachers and promote critical thinking skills through the use of an integrated, inquiry-based program. The FHSU-NOVA project objectives were to: 1) improve preservice teachers' awareness of teaching mathematics and science using an inquiry-based model, and 2) provide preservice teachers with exemplary learning experiences that would serve as referents to use in methods courses and in subsequent teaching experiences as they develop a theory of praxis.

The courses taught by members of the collaborative team were Physical Science, Physical Science Laboratory, Elements of Statistics, and Mathematics and Science Methods. Through coordination of teaching efforts, students in each of the three courses do not just "hear" or "see" inquiry learning, but experience learning through integration of curriculum. Experiences in each course provided a foundation for students to develop teaching and assessment plans. Table 1 provides an overview of course attributes of the 1997 version of the courses and the final revision of the courses. The revised courses reflected a major change in assessment, teaching methods, and connection to the standards over previous offerings. Instruction changed to include more cooperative group work with an emphasis on inquiry-based activities and the NASA Strategic Enterprises. Portfolios, projects, paper and pencil tests, presentations, peer and instructor assessment of cooperative learning, and reflective activities such as journaling were used to assess preservice teachers' knowledge and skills.

Technological literacy played a major role in the revised courses. Students used computers for many learning activities, which in 1997 was a new thrust for the institution. For example, NASA materials and data were readily available through Web-based learning. Students also used hand-held data collection and analysis tools.

Table 1 Course Attributes

Current Courses	Revised Courses
Science laboratory separate from course	Laboratories integrated with the courses
Great breadth of topics without a focus on key concepts	Course content reorganized to emphasize key concepts
Technology (WWW, CBL, Graphing Calculator) is not effectively integrated with class content	Technology used for assessment and integrated with class content
Teaching/learning is primarily teacher-centered with limited use of inquiry methods; students primarily assume a passive role	Teaching/learning has become more student-centered and inquiry-based with the teacher assuming a facilitator role
Students are evaluated through use of pencil and paper tests with limited use of alternative assessments (projects, presentations, portfolios, etc.)	Students assessed using multiple strategies with an emphasis on assessment that is seamless with instruction
Course topics are not well integrated into thematic units	Course topics integrated through use of units aligned with the NASA's strategic initiatives and the National Science Education Standards, National Council of Teachers of Mathematics standards, and state curricular standards in mathematics and science
Students' prior knowledge of science, mathematics, and teaching, is ill-defined and not used in planning instruction	Students' prior knowledge documented through pre-/post assessments in each of the courses and instructors cooperate on teaching and learning in each of the courses

NOVAII

FHSU received a second NOVA grant in 1999. The objective for the second project was to develop a capstone course as a follow-up to the statistics and physical science courses. The intent was to develop a course that integrated across the sciences, social studies, and mathematics. The approach was taken to provide preservice elementary teachers content and examples of how to integrate across the disciplines when teaching.

The course we developed focused on navigation and used Dava Sobel's book "Longitude" as a foundation. Topics ranged from ancient navigation techniques to GPS. Along the way the fundamentals of magnetism were taught, a bit of animal navigation, and mathematics of calculating longitude using a sextant. The course outcomes and effectiveness were measured. While the course was successful in teaching content, and showing the students how to integrate across multiple disciplines, it was not sustainable. Though it was fun and interesting to teach from both a student and faculty perspective, possibly more so on the faculty side, the expertise required to teach the course made – only one faculty member had the wide background needed to address the multiple topics – made it difficult to offer the course in a regular rotation due to departmental workload needs. Despite this the course served a vital role – it forced the team to examine the intended goal and take different tack, the result was a proposal to the National Science Foundation as described in section.

Evaluation of effectiveness

The overall goal of the FHSU NOVA Project was to provide preservice K-9 teachers with an integrated science and mathematics curriculum enriched by the NASA Strategic Enterprises, technology use, and collaborative teaching. Quantitative and qualitative methods were used to assess this goal.

Quantitative Research

The University of Iowa as part of the Salish Research Project developed the instruments used for the quantitative analysis of the FHSU Project NOVA. The survey instruments *Nature and Implication of Mathematics* and the *Nature and Implication of Science* were given in a pretest-posttest format to measure student attitude toward the subject. The *Nature and Implication of Mathematics* was administered to *Elements of Statistics and Mathematics* and Science Methods students; the *Nature and Implication of Science* was administered to Physical Science, Physical Science Lab, and Mathematics and Science Methods students. The *Constructivist Learning Environment Survey* (Taylor, Fraser, & White, 1994) was given to students in all three courses at mid-semester to measure the classroom learning environment.

The results of a quantitative analysis of attitude and classroom environment are mixed. A two-sample t-test was used to calculate p-values with a = .10 as the significance level. The findings are not consistent between classes or semesters. For example, during the spring 1998 semester, the results of one section of Elements of Statistics were statistically significant when measuring students' attitudes about the usefulness of mathematics (p = .0690), while the other section was not (p = .9481). The results of both sections were, however, statistically significant when students' attitudes on the nature of mathematics were measured (p = .0001 and p = .0412). The same instructor, using the same set of lesson plans and activities, taught both sections of Elements of Statistics. The *Nature and Implication of Mathematics* often showed statistical significance on student attitudes about the social implications of mathematics. The *Nature and Implication of Science* showed statistical significance most frequently on student attitudes about the usefulness of science in the Physical Science and Mathematics and Science Methods classes. The *Constructivist Learning Environment Survey* showed some statistical significance in student negotiation in Elements of Statistics and Mathematics and Science Methods classes, indicating students felt their wishes were considered in classroom decisions.

Qualitative Research

One form of qualitative analysis was performed using a survey developed by the FHSU Project NOVA team. The survey was administered to all students in the course sections participating in the project at the end of the semester. The questions were:

1) What teaching methods have you experienced in this class?
2) Are these teaching methods different from those used in other classes?
3) What are the most effective teaching methods used in this class?
4) How do you learn best?

Results showed students noticed the emphasis on cooperative, hands-on learning and recognized these classes were taught differently from others they have taken. Students also rated these techniques as the most effective used in teaching the classes, and indicated they are more successful when hands-on and cooperative learning are used. Further investigation should be completed to determine how these ideas translate to the methods course.
An informal qualitative assessment based on the perceived results observed by FHSU NOVA team members was also conducted on specific outcomes of the project. Outcomes for preservice K-9 teachers included the following:

1) increase critical thinking through use of an inquiry-based approach for teaching,
2) integrate concepts and process inherent in mathematics and science,
3) develop teaching strategies to incorporate cooperative learning techniques,
4) improve disposition toward an increased interest in mathematics and science,
5) model effective inquiry-oriented thinking for peers and students, and
6) align with national/state mathematics and science standards.

Evidence of the success of these outcomes was observed by the NOVA team at the conclusion of the project. Success was demonstrated through student work such as individual and group projects, investigative reports and research studies, lesson plans, and student use of multiple forms of technology.

Benefits and Drawbacks of FHSU Project NOVA

Perhaps the greatest benefit of this curriculum redesign project was the collaboration that developed among the FHSU NOVA team members. By visiting each other’s classes, through hours of discussions and teaming sessions, and by sharing expertise, we have designed a cohesive plan for enticing students to engage in science. By heightening our own use of technology, inquiry-based learning and content our students have benefited. Preservice teachers in the Mathematics and Science Methods course indicated appreciation for the references and links made to what was done in Physical Science and Elements of Statistics.

Other benefits observed in the NOVA courses were: 1) heightened awareness of NASA and the benefits to using NASA resources; 2) an institutionalization on the part of the preservice teachers of hands-on learning and problem-based teaching which is contrary to many of their previous science and mathematics formal learning experiences; and 3) reduced anxiety toward teaching mathematics and science because of increased content knowledge and methods for addressing the needs of children. Though frustrated at first, preservice teachers also appreciated the open-endedness of lessons and the increased emphasis on process as well as product. For many, this was a large paradigm shift.

The most serious problem associated with FHSU Project NOVA was lack of time. All team members taught at least 12 hours each semester and reassigned time for curriculum development is a rather illusive commodity. The team spent a great deal of personal time attending strategy and technology workshops, preparing detailed lesson plans, attending each other's classes, and sharing knowledge. Personalities of team members must be compatible in order to achieve success under these circumstances. FHSU Project NOVA benefited both faculty and students. Faculty were given the opportunity to develop collaborative bonds that transcend department and college boundaries. Preservice teachers received the tools and knowledge necessary to create a critical thinking and inquiry-based learning environment for their future students.

Retrospective Impact

The NOVA project at FHSU was very significant in shaping the future of the faculty members involved in the project at the time. Publications of the work, collegial relationships, and breaking of departmental and college borders have been very fruitful as will be described further in this paper. The courses developed as part of the original NOVA have evolved as faculty moved on and new faculty came to the university. The one course that appears to have retained some of the original work was the Physical Science Laboratory. The Statistics courses have returned to a more traditional model. Elements of the original NOVA program have been retained in the Elementary Science Methods Class and as part of an after-school science program. The Physical Science course has continued to evolve to several more years, as will be described, but is currently undergoing a change to reflect a change in departmental goals related to sustainability and energy. One element has remained as a direct result of the NOVA effort. Faculty partnerships to produce innovative undergraduate science education as is described in the next section of the paper.

THE GROWTH YEARS: TWO NSF GRANTS AND EXPANDED HORIZONS

Integrating Exemplary Physical Science Teacher Enhancement Materials with Mathematics for Preservice Teachers (NSF DUE-0088818)

The experience of the core NOVA team with NOVAII, Navigation, helped us understand that we needed a better approach in teaching integrated science, develop the skills of teachers to conduct scientific research, and integrated across disciplines. The NOVA core team, Adams and Taggart, decided to take the experience from the original NOVA efforts and develop a proposal to the National Science Foundation to develop a science and mathematics course that integrated mathematics, science, content area reading, and undergraduate research. The new team consisted of a geoscientist, physicist, mathematician, teacher education, biologist, and chemist.

The organizational structure of the course used the overarching themes in the National Science Education Standards, with a specific focus on cycles: water cycle, nitrogen cycle, sound, climate, life cycle, carbon cycle, cycles in the body, and time. The semester long course was team taught, provided background instruction on the nature of science and development of numerical skills, covered four cycles a semester, and required an extended time on a research project. Outcomes of this project have been reported in Hohman et. al, 2007; Taggart et. al; 2007 and Adams, 2005.

Several outcomes can be attributed to the course. First the faculty involved, specifically the geoscientist, fundamentally changed the way that he teaches and assesses students. The project also led to an enduring partnership for development of innovative undergraduate courses that continues to this day; this will be summarized in the conclusion. All team members, based on the evaluator comments, changed the way they teach in the classroom (Adams, 2005). We also found that the student driven research experience was one of the most important aspects of the class. The course, as conceptualized at the time has moved on and become a new class, Global Climate Change, that has now been offered for the last three years.

As the course was taught and evaluated, we found that the elementary teachers did not have sufficient background or skills to fully engage and benefit from the course. To address this issue the team applied for a second National Science Foundation Grant (NSF DUE-0311042) with the intent of revising and improving the Physical Science course developed for NOVA in light of our experience.

CASE STUDY: ***Adapting Operation Primary Physical Science for Use in a Physical Science Class*** **(NSF DUE-0311042)**

The overarching goal of this project was to improve preparation of prospective K-8 teachers with respect to content and process knowledge of the physical sciences, as well as to improve their pedagogical content knowledge related to teaching science. A missing component identified for achievement of this goal was preservice teachers' lack of experience with exemplary content/pedagogical models starting with foundation courses. Therefore the key college science course for prospective K-8 teachers (Physical Science) was modified to utilize teaching strategies that have been shown successful in learning science at the elementary level. For this purpose Operation Primary Physical Science (OPPS) (Louisiana State University, 2005), an exemplary teacher enhancement project (National Academy of Sciences, 2005), was adapted and extended. OPPS modules are organized by topics and content is concentrated on real-world situations as authentic learning contexts. The OPPS utilizes a five-step (commonly known as 5E) variation of learning cycle model (Marek & Methven, 1991) and promotes cooperative learning and peer instruction.

Fort Hays State University was an OPPS field test site 1996 – 2001. The materials proved effective in developing teachers' knowledge of science and pedagogical content knowledge. However researchers realized the need to additionally emphasize mathematics, link materials with Mathematics Standards, and make the "big picture" of the content more visible during the course of study. For this purpose, readings from standard texts and various reading strategies (Barton & Jordan, 2001) were integrated into the modified course

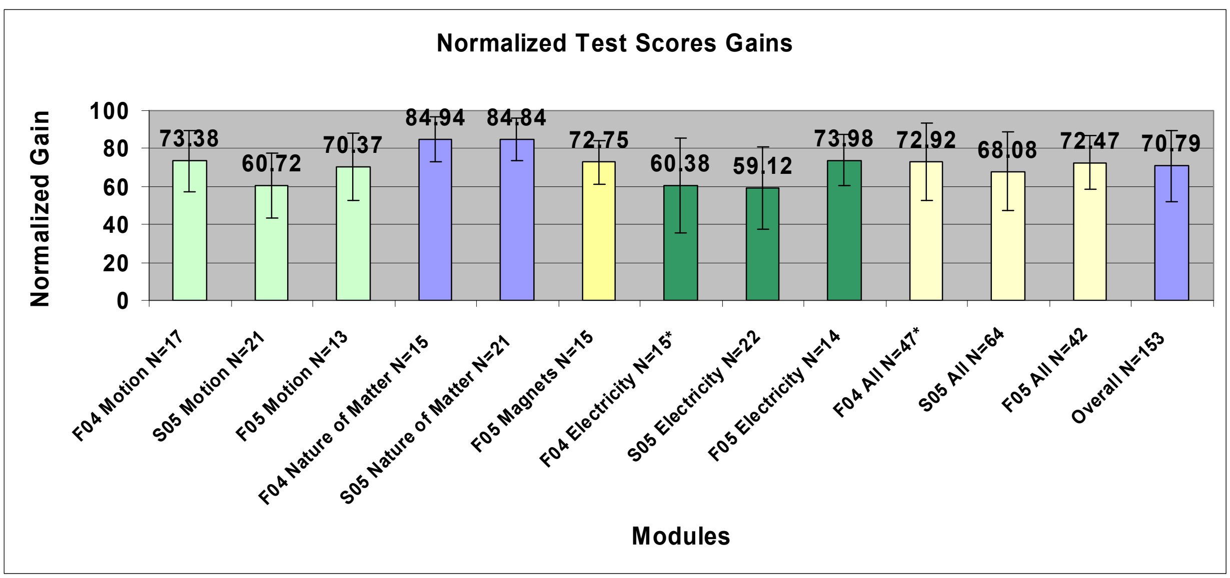
Two main research questions during the course implementation were (1) whether students learn content in this modified course and (2) what are their attitudes toward the modified teaching setting.

Evaluation

After adaptation, selection, and refinement of OPPS materials in summer of 2004, the modified Physical Science course was offered and finalized during Fall 2004 (F04), Spring 2005 (S05) and Fall 2005 (F05). The content learning in the course was assessed through pre-post knowledge gains to address research question 1. Student attitudes (second research question) were assessed through (i) Focus group interviews (to elicit students' feedback and general impressions), (ii) The Colorado Learning Attitudes about Science Survey (CLASS) (W. K. Adams, Perkins, Dubson, Finkelstein, & Wieman, 2004) (to elicit students attitudes about learning science) and through Constructivist Learning Environment Survey (CLES) survey (Taylor, Fraser, & White, 1994) (to gauge students' perceptions of the learning environment i.e. its alignment with constructivist learning paradigm). The same instructor was teaching the modified course in all three semesters (F04, S05, F05) while study was conducted. Although our research questions were focused on performance of the modified course alone, we contended that comparison of the modified course with a lecture based course could be rather informative as well. Therefore, as a reference point, we administered both CLASS and CLES surveys to students enrolled in physical science course delivered in traditional, lecture based method . With comprehensive results described elsewhere (Adams et al., 2007), in this report we concentrate on student learning gains.

Pre- and Post- Instruction Testing

Learning gains in content knowledge were measured for each module through pre- and post-instruction tests earlier developed by authors of OPPS. These tests target conceptual knowledge and simple experimental design ability. Normalized gain is the percentage gain achieved divided by the total possible percentage gain or: Normalized Gain = (post-test% - pre-test%) / (100% - pre-test%). Hake (Hake, 1997) argues that a normalized gain is an accurate measure of the effectiveness (or non-effectiveness) of a particular presentation style. Learning gains are shown in Figure 1 (where N represents number of students).



* One outlying data point eliminated

FIGURE 1. Normalized Content Knowledge Gain Scores for Modules and Semesters.

All pre-post gains in test scores shown in Figure 1. are significant at the .01 level on a two–tailed t-test. In Figure 1, an outlier was eliminated from one module but gains are significant at the same level even with this data point included. This outlier was removed because it gives a false impression of the gain and the standard deviation associated with the respective module. This finding indicates that students do learn content in the modified course.

Synergistic Effects and Outgrowths

Fort Hays State University initiated a campuswide mobile computing program in 2005 and in the Summer semester of 2006 (U06) our modified physical science course was one of the several courses chosen for pilot implementation of Tablet PCs combined with interactive software called DyKnow (www.dyknow.com).

During the first implementation (in U06) it 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 (Hrepic, 2008a, 2008b; Hrepic, Rebello, & Zollman, 2009). 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 (Hrepic, 2007; Hrepic et al., 2009).

Similarly, in further deployments (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) (Hrepic, 2008a, 2008b; Hrepic et al., 2009). These results prompted us to further investigate what effect, if any, this technology had on student learning in this type of largely hands-on and discussion-oriented course.

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 again deployed the same, externally developed (Louisiana State University, 2005) tests that were used in the course during the F04-F05 semesters.

Evaluation

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 2: 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

Table 2: Normalized Content Knowledge Gain Scores for Modules and Semesters

Figure 2 (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).

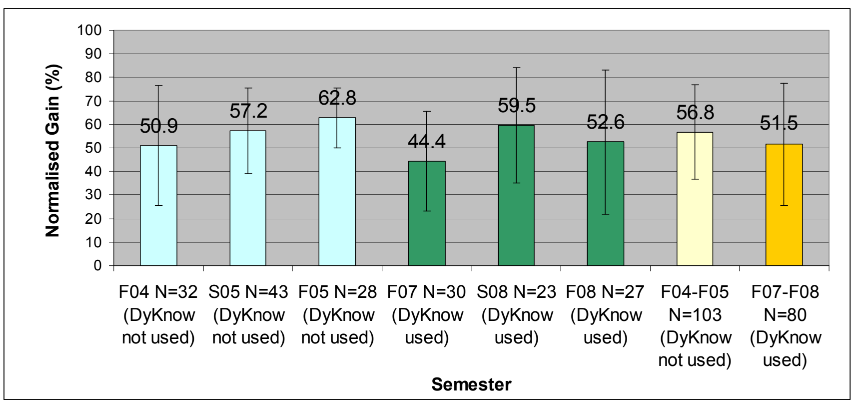


Figure 2: Normalized gains for electricity module and motion module combined per individual semesters and semester groups (F04-F05 vs. F07-F08 semesters).

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 (Hrepic, 2008a, 2008b; Hrepic et al., 2009) (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) (Hrepic, 2008a, 2008b; Hrepic et al., 2009).

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 (Hrepic & Reed, 2009). This analysis revealed in some respects opposite trends for these two content areas (Table 1). Gain for electricity module 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 ($p= 0.0008$). Details about gain dynamics for two modules individually were also discussed elsewhere.

In conclusion, 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 (Hrepic, 2008a, 2008b; Hrepic et al., 2009), 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 and favorable attitudes of students toward this technology encourage further investigation of instructional options enabled by this technology, their possible benefits and optimal ways of employing them.

Students do learn course material in the inquiry based course developed in this study as shown by significant learning gains for all tests in all semesters. Students' overall attitudes toward the class (as found through focus groups and online surveys) were positive, especially toward the end of the each semester. This shows that the methodology was well accepted, but students were typically not initially use to it. It sometimes took more than half of the semester for students to get accustomed to inquiry based methodology so their attitudes become favorable.

Focus group attitudes and students' learning strategies (CLASS survey) were more favorable in F04 and F05 than in S05. Because the same instructor was teaching the course both times, with equal attitude, and covered the same content, it seems that non-curricular factors, such as students' expectations, interpersonal dynamics and communication skills may considerably affect students attitudes and learning approaches. Other possible sources of differences were size of the group (slightly smaller in F04 and F05 than in S05) and students' comfort with expressing opinions (more outgoing groups in F04 and F05).

Introduction of technology in follow up deployments however dramatically sped up student comfort with the methodology is well as overall attitudes toward the class.

Although the modified course was targeted toward preservice elementary school teaching majors, not all of our students were from this population in any of the semesters. Our circumstantial evidence indicates that on average preservice elementary teachers had more difficulties accepting and embracing the inquiry based course than other students who seem to have higher self-efficacy and were less intimidated by the prospect of open investigation.

Regardless of the class personality, our experience indicates that, because student interaction and engagement play crucial role in this course, it is very helpful to spend first 2-3 classes at the beginning of the semester getting students to know each other and building their team work skills through group activities not related to the course content. At this time, it is also necessary to thoroughly describe the methodology and expectations from students. And learning technology such as Tablet PCs combined with interactive software seems to have a great potential in facilitating this process.

Overall, this project showed the utility and transferability of excellent teacher enhancement materials (OPPS) to preservice teacher preparation. A possible broader impact of this finding is providing the starting point for similar innovations in other college science courses.

Directly or indirectly, this science course, with follow-up implementations and technology associated investigations has resulted in a large number of publications:
(Adams et al., 2007; Hrepic, 2011; Hrepic et al., 2006; Hrepic, Curtis, & Bonilla, 2008; Hrepic et al., 2009; Hrepic & Reed, 2009; Wang, Gould, et al., 2007; Wang, Hoopingarner, Weigel, Hrepic, & Fulton, 2007; Wang & Hrepic, 2007)

NEW HORIZONS

Hrepic, who had lead responsibility on the second NSF grant, has left FHSU and moved on to Columbus State University in Georgia. Currently the curricular material used at CSU in equivalent inquiry-based class for elementary education majors is PSET. The reason it was adopted is that it has a quite wide scope that covers all the required Georgia standards for this course. After using this nationally acclaimed curriculum for several years Hrepic reports without hesitation that curricular material developed at FHSU site is of high quality as it easier lends itself to genuine student investigation and requires/applies much higher mathematical skills then PSET material. However, with FHSU material all the materials are covered in much greater depth, it is therefore necessary to cover smaller number of modules. And not covering all of the content in accordance to Georgia standards did not make this material plausible option for usage at CSU.

At FHSU there have also been changes. Of the original NOVA team only Adams and Taggart remain. Taggart has become a department chair is now primarily in administration with limited opportunities to teach. Adams accepted an endowed chair position within the university in Teacher Education but has also maintained an appointment in the Physics Department. Of the other team members brought onto the team, the chemist, Hohman, became a department chair and the geoscientist, Heinrichs, also became a department chair. All other members have retired or moved on to other positions.

Time-to-time Adams and Hohman discuss possible undergraduate science projects but at this point there has not been any substantive projects. However, in the case of Adams and Heinrichs, and enduring partnership has formed that has lasted to current time. The team have collaborated on the development of four courses, all of which have had their foundation on the work presented here. The course are:

Planetary Science - a graduate course for teachers and science majors. The key elements retained from the other work deal with assessment and use of technology. The course is offered on a bi-annual basis,.

Global Climate Change - undergraduate course that is the successor to the NSF grant on integrated science. The course is offered in the fall semester of each year. Critical to the course is a research project by the students. The course is scheduled for updating and replacement in the fall of 2012.

Aerospace Technology - upper division undergraduate/graduate course that engages student teams to build a rocket that will fly to an altitude of one mile and a balloon (with recovery) to an altitude of 80,000 feet+. The pedagogical module of the course is patterned after our first NSF grant and involves engaging students in research.

Research in the Earth Sciences - undergraduate course that will be the successor of the Global Climate Change Course. The course is currently under development.

Conclusions

The NOVA project provide a solid foundation to establish a cross-disciplinary team to engage in educational innovations to improve undergraduate science education. The implication of other institutions is building this network. It is difficult to maintain, as individuals move forward with their careers and lives, but once entrenched serves as a fertile ground for continual renewal and growth of the faculty and the curriculum.

On reflection we have seen that what is wonderful in improving student learning in undergraduate science changes based on the personnel and needs. While the courses we have developed have not all survived, the current revisions are more responsive to the needs of our state and students. What has stood the test-of-time is student engagement in the learning process, possibly through research projects or inquiry-driven classroom activities, Another aspect that has remained throughout our efforts has been the a move from paper-pencil assessment to rubric-based assessments.

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