Changing Instructional Practices and Achievement: Longitudinal Analysis of an Inquiry-Based Technology Curriculum

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Abstract

Literacy and reading gains are foremost on the list of student outcomes that educators are called to address under the No Child Left Behind act. The present paper describes one project's efforts to support teachers' implementation of an inquiry-based, non-fiction, technology-infused curriculum. Positive progress is evident in the level of strategy use by teachers as well as the improvement in technical proficiency. Analysis of implementation show that learning activities and strategy use in the IBL units are strong; however, there is wide variability in the duration of the intervention experienced by students in different classrooms. In terms of student achievement, several relationships emerged from the mixed model linear regression analyses. The length of time students have participated in the program and levels of teacher strategy use are significantly related to student reading achievement.

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Purpose

Literacy and reading gains are foremost on the list of student outcomes that educators are called to address under the No Child Left Behind act. The present paper describes one project's efforts to support teachers' implementation of an inquiry-based, non-fiction, technology-infused curriculum.

Theoretical Framework

Research supports the notion that changes at the instructional and classroom level can influence reading comprehension (Aarnoutse, Van Leeuwe, Voeten, & Oud, 2001), though the relationship is complex (Connor, Morrison & Katch, 2004; Juel & Minden-Cupp, 2000). Investigations of these relationships using linear modeling analysis techniques suggest that of amount and type of reading instruction depended on children's initial reading comprehension skills (Connor, Morrison, & Petrella, 2004). Change is evident not just in magnitude of change but also the rate students' comprehension changes.

The National Reading Panel outlines several components to effective reading instruction. These components include phonemic awareness instruction, systematic phonics instruction, guided oral reading, vocabulary instruction, and comprehension strategies instruction. The panel asserts that comprehension strategies with positive affects on student understanding include student meta-understanding of their own comprehension, use of graphic/semantic, attention to story structure, questioning, visualization, and summarizing (NRP, 2000).

Reading comprehension is grounded in fluency. Readers must be fluent in recognizing words, vocabulary and knowledge needed to think critically and broadly (Chall & Jacob, 2003). Fluency is an important factor in developing proficient readers (NRP, 2000). Specifically, fluency refers to the readers' ability to quickly and accurately recognize words and serves as an important bridge to reading comprehension. Although fluency is not the same as decoding, decoding is a crucial element. The inability to quickly to decode and recognize words impairs the metacognitive activities of the reader, thus negatively influencing reading comprehension (Curtis & Longo, 1999b). Fluency is positively affected by repeated reading, metacognitive reading strategies, extensive independent reading coupled with explicit instruction in understanding text structures, language structures, and text content (NRP, 2000). Fluency develops as students build vocabularies. By introducing and focusing on the words they need to study teachers in the content areas can improve fluency as part of subject-specific learning (United Federation of Reading Teachers, 2004).

The tenets of reading comprehension form a natural parallel with inquiry approaches to understanding complemented with explicit strategy instruction. This is clear when inquiry is conceived, not as a strategy or method, but rather as "a philosophical stance an educator takes…one that uses these students' questions to frame curriculum rather than only to assess students' mastery of curriculum…" (DuVall, 2001, p. 3). How is inquiry operationalized into actual classroom instruction? Sullivan (1999) utilizes a four-part model in her classroom: raising questions, searching multiple resources, grouping to integrate information, and sharing conclusions. On the other hand, Short, Harste, & Burke (1996) relate inquiry to the cyclical authoring process. They believe that inquiry begins with what the student already knows: personal and social knowledge. From this knowledge, students are given time to ask questions and gain new perspectives collaboratively. This includes recognizing and reconciling differences and culminates in sharing new knowledge, taking action, and planning new inquiries.

Vocabulary development is central to comprehension and content learning and should include different strategies embedded in instruction in content and fiction. (Nagy, 1988; Curtis & Longo, 2001) Instructional activities must help students access and use prior knowledge (Johnson, 1981). Students also need explicit instruction in semantic structures of text (Johnson et al. 1986).

Research has also shown that the three priorities of effective vocabulary instruction are: integration, repetition, and meaningful use. Intensive instruction is needed if new words are to be incorporated into students' writing or speaking vocabularies (Duin & Graves, 1987). "Considering the large number of words students encounter and the need to learn them, it is obvious that all of these words cannot be taught …. We need to encourage students to be aware of and interested in words so that students develop ownership of them."(Cooper, 2002).

The idea of inquiry-based learning as a tool for improved content knowledge (e.g., in science or social studies) is not new (Chittenden, Salinger, & Bussis, 2001; Friend, 2000; Guthrie, Schafer, & Huang, 2001). However, the notion that an inquiry based curriculum could improve student reading achievement may not be readily apparent. Translating inquiry into the classroom involves questioning, multiple resources, collaboration, and sharing conclusions (Sullivan, 1999).

It can be a cyclical authoring process (Short, Harste, & Burke, 1996). No matter what the components, students' personal and social knowledge is forefront in sharing new knowledge, taking action, and planning new inquiries. Calls for educational reform by infusing inquiry into students' learning activities are based on increased content knowledge as well as improved motivation and engagement, especially in reading and writing (Cambourne, 2001; Palinscar, Magnusson, & Cutter, 2002; Worthy, 2000). Purposeful tasks and authentic connections are crucial elements of the inquiry based classroom as well as important driving forces to engage students in reading (Yore, Craig, and Maguire, 1995). Engagement in the reason for reading results in a more thoughtful, enhanced reading experience (Duffy, 2003a; Harvey & Goudvis, 2000). This engaged reading time translates into reading achievement (Guthrie, Schafer, & Huang, 2001).

Bringing the components of effective technology integration, inquiry, and nonfiction together to address the needs of our most at-risk students is a daunting task, but the value of this commitment is clear. The comments of Kozma and Croninger (1992) remain relevant more than a decade later. "Teachers, school administrators, and policy-makers (must) ensure that all students have access to these technologies, that the technologies are used effectively, and that other aspects of schooling also promote high levels of student learning" (p.440).

System issues (like access, planning and vision), teacher issues (like skill, pedagogy, and comfort level), and the interaction of these with computing and digital technologies for K-12 classrooms have been considered as key agents in complex models of change (Hunter, Bagley, & Bagley, 1993; Mehlinger, 1997; Tetreault, 1998; Odom & Griffin, 1999).

Claims of the effects of these technologies touch learners in many ways: attitudes, thinking, collaborative skills, and most importantly, in this age of heightened accountability pressures, standardized tests scores across skill and content areas (Hill, 1993; Means & Olsen, 1997; Wenglinsky, 1998; Rampp & Guffey, 1998; Honey, Culp, & Carrigg, 1999; Mann, Shakeshaft, Becker, & Kottkamp, 1999; Schacter & Fagnano, 1999). The excitement of these claims is amplified by studies suggesting that minority students and students at-risk due to poverty or learning problems are not excluded from these gains when sound projects are implemented (Kozma & Croninger, 1992; Diggs, 1997; Alfaro, 1999; Thornton & Wongbundhit, 2002). Access to technologies is the key to opening the benefits to these students – access to files, telecommunications, and interactive services to bridge the real inequities that exist (Center for Science, Mathematics, and Engineering Education, 1995; Means and Olson, 1997). The mediating factors influencing the role of technology in learner achievement have been a primary focus of researcher attention. The idea that technology's influence does not occur in a vacuum but rather is inextricably linked to instructional practice as informed many models for "best practices" in the effective integration of technology (Harel & Papert, 1990; Means et al., 1993; Tetreault, 1998; Schacter & Fagnano, 1999; Krajcik, Marx, Blumenfeld, Soloway, Fishman, 2000; Sherry, Billig, Jesse, & Watson-Acosta, 2001). Many projects have recognized the key role of teachers as an important change agent, especially in the integration of technology into daily instruction (Cradler & Cradler, 2000). Access to a sound infrastructure, both human and technological, is also considered a key prerequisite to sustained reform (Cradler & Beuthel, 2001).

Research has shown the use of technology to a motivating factor, improving student interest and engagement (Carnahan & Cobb, 2004; O'Brien, 2003). Motivation is not just interest in or an attitude about a subject, but indicates active engagement and leads to self directed learning by students (Hurst, 2003; Kamil, 2003; Snow & Biancarosa, 2004). Projects with higher levels of technology integration have been linked to higher reading scaled scores in reading and math (Middleton & Murray, 1999). In inquiry-based learning models, students participate in a variety of language and literacy experiences as they answer questions that lead to understanding. The use of computer related technology has been found to particularly effective in implementing an inquiry-based curriculum, and offers opportunities for expanding students' reading and writing processes into multimedia composition and comprehension (Owens, Hester & Teal, 2005).

Many projects have recognized the key role of teachers as an important change agent, especially in the integration of technology into daily instruction (Cradler & Cradler, 2000). Access to a sound infrastructure, both human and technological, is also considered a key prerequisite to sustained reform (Cradler & Beuthel, 2001). Specifically, teachers need to know how to use and have access to the additional resources as well as to the application they have selected; an awareness of and access to timely technical guidance; to use technology applications that are consistent with their own teaching practice and pedagogy, the social dynamics of the school, the school culture (collaborative or individualistic), and the curricular goals of the school and district; and colleagues who will support and mentor them through the implementation of their innovative efforts. Teachers need time to design and receive feedback on complex new units. They need to observe others and work collaboratively to reshape curriculum aligned to content standards. And of course, they need improved technical skills. Schools and districts need a thoughtful vision and clear plans for all these effective implementation elements to come together (Breithaupt, 2000). Some have even suggested that healthy change is progressive rather than revolutionary. School environments need to include healthy human infrastructure and functional and convenient technical infrastructure (Zhao, Pugh, Sheldon, & Byers, 2002).

Inquiry units are constructed in order to allow students to study content that is relevant and meaningful to them. In order to have students successfully conduct inquiry a wide range of resources must be made available. Teachers need to "put the right books in students' hands," books that have interesting content but are easy to read (United Federation of Reading Teachers, 2004). Instructional improvements should include the use of diverse texts, and text based collaborative learning (Snow & Biancarosa, 2004). What does research say about the value of nonfiction? First, research suggests that even young children are capable of understanding nonfiction (Pappas, 1991; Pappas, 1993; Kamil & Lane, 1997; Moss, 1997; Duke & Kays, 1998; Yopp & Yopp, 2000). Research also suggests that nonfiction texts produce positive affective outcomes for students in the form of increased motivation and interest in reading (Doiron, 1994; Caswell & Duke, 1998; Leal & Moss, 1999). Finally, informational books serve numerous purposes, including exposing children to a variety of text features and structures, specialized vocabulary, building background knowledge, the shifting nature of discussions and activities that contributed to understanding the purposes and processes of reading—these serve as a “catalyst to literacy” (Yopp & Yopp, 2000, 413). As students progress to higher grade levels their exposure to non-fiction text increases. Because the structures of informational text vary from those of narrative text, students need exposure to non-fiction to build the skills needed to read these types of texts fluently (Fielding & Pearson, 1994; Yopp & Yopp, 2000).

Finally, the importance of the model chosen for teacher professional development is clear. Ingvarson, Meijers, & Beavis (2005) argue that there are five major elements that need to be considered: content focus, active learning, feedback, follow-up and collaborative examination of student work. Cohen and Hill (2000) assert that professional learning is more likely to improve student learning outcomes by increasing teachers’ understanding of the content, how students learn that content, and how to represent and convey that content meaningfully. In addition, teachers' reflections on their current practice in relation to professional standards is key to successful professional development. Similarly, teachers need to actively reflect on the developmental appropriateness of what students are learning compared to what they are capable of learning (Ingvarson, Meiers, & Beavis, 2005; Hawley & Valli, 1999). Coaching support for teachers along with co-planning and co-teaching in the area of literacy instruction has also shown to be promising (Dicker & Little, 2005; Kamil, 2003). Finally, effective training must also be based on sound adult learning strategies that include “just in time” support in several forms (McKenzie 1998).

Ideas on how to best frame technology-rich instructional activities in ways that maximize positive outcomes have been steadily evolving. (Schacter, 1999; Wang, Laffey, & Poole, 2001). Practitioners have worked hard to translate these theories of technology integration practices into effective training and teacher preparation models (Means & Olson, 1997; Sparks, 1997; Sparks & Hirsh, 1997; Middleton & Murray, 1999; Mills, 1999; Sparks, 1999; Killion, 2000; Christensen, Griffin, & Knezek, 2001; Shibley, 2001; Thornton & Wongbundhit, 2002; Zhao, Pugh, Sheldon, & Byers, 2002). Specifically, teachers need to know how to use and have access to the additional resources as well as to the application they have selected; an awareness of and access to timely technical guidance; to use technology applications that are consistent with their own teaching practice and pedagogy, the social dynamics of the school, the school culture (collaborative or individualistic), and the curricular goals of the school and district; and colleagues who will support and mentor them through the implementation of their innovative efforts. Teachers need time to design and receive feedback on complex new units. They need to observe others and work collaboratively to reshape curriculum aligned to content standards. And of course, they need improved technical skills. Finally, effective training must also be based on sound adult learning strategies that include "just in time" support in several forms (McKenzie 1998). Activities that are sustained and intensive in addition to content-focused need to be integrated into daily school life to produce desired results (Dole, 2003; Garret et al., 2001). This element of "coherence" is supported by linking professional development to teachers' other experiences and other school reforms, building teacher communication and collaboration outside of training activities as well as the collective participation of groups of teachers from the same schools, grade levels, and content areas (Duffy, 2003b; Garret et al., 2001).

I.t.'s R.E.A.L. (Inquiry + Technology + Science/Social Studies + Reading/Riting/Rithmetic = Engaging All Learners) increases students' academic achievement in reading as they learn to acquire and analyze information, make decisions, and communicate findings. It uses a model of professional development (Alford, 1998) designed to enrich teaching skills so that the teachers can engage their students in authentic tasks. The instructors use inquiry-based strategies throughout the trainings in order to model the methods for the participants.

At the student level, this project incorporates inquiry methods and technology to address the needs of all learners.

I.t.'s R.E.A.L. infuses explicit reading strategy instruction into content area units of study in every class. A five step process of inquiry is used as the basis for instruction: encountering the issue, task analysis, investigating information, reasoning with information, and acting on decisions. The units developed as a result of this model have an “authentic connection” which is a request from someone beyond the classroom for assistance in the creation of some informational product which has a real audience and real purpose. In order to truly engage students, this cannot be a contrived invitation to learn. Students work collaboratively, ask questions-answer questions, ask some more and activate prior knowledge as they explore and reason with information throughout the inquiry process.

The students develop the questions that need to be answered, help choose the form or forms the information will take in the final product, seek information from multiple sources including texts, and nonfiction leveled reading materials. They use technology to access online sources, communicate with experts and their peers outside of the classroom, and develop and deliver the final product. They develop textual literacy, visual and technological literacy as well.

I.t.'s R.E.A.L. incorporates explicit instructional strategy activities, to provide students with the skills needed to use inferences, synthesize main points, apply appropriate reading strategies to fiction and nonfiction texts, and select reading strategies fro text appropriate to the reader's purpose.

I.t.'s R.E.A.L. helps build fluency through explicit instruction in vocabulary and the features and structures of nonfiction texts. Teachers model fluency and metacognitive strategies through Read Alouds and other instructional activities. Students have opportunities for repeated readings of important texts and extended reading of content related, leveled, nonfiction texts. The model uses explicit vocabulary instruction within the inquiry teaching and learning events. Students are given instruments to allow them to independently track words in the variety of reading texts and online sources as they encounter them in context. Teachers introduce important content related vocabulary at the very beginning of the unit. They use instructional activities that check and help recall prior knowledge. Explicit instruction in the features and structures of nonfiction text helps students deal with difficult content specific vocabulary. Finally, students apply word analysis and vocabulary skills to comprehend selections. They use strategies to understand the essential qualities of the words, analyze word usage, as well as discern meaning by comparing features of words in the same category or class, prereading predictions, prior knowledge, and semantic feature analysis.

The I.t.'s R.E.A.L. instructional model uses the recommendations of the research and literature relating to motivation to actively engage learners. Every inquiry unit has an authentic connection to the real world so students can see the value of what they are being asked to investigate. Content specific, nonfiction, leveled reading books supplement the textbook. Students select texts that they can and want to read as they seek answers to questions they have developed. Technology is used to give students access to timely information, as a means of communication and to construct real products for a real audience. And finally, students work collaboratively throughout the units, asking question, seeking, finding and sharing information. Working in teams they reason with information from multiple sources, and synthesize it into a final team product. Students apply acquired information, concepts and ideas to communicate in a variety of formats.

The model focuses on the implementation of research-based nonfiction reading strategies in the content areas. Theses strategies help students comprehend classroom texts. In addition sets of high quality, leveled reading, nonfiction books are purchased for each unit.

I.t.'s R.E.A.L. trainings are designed to enrich teaching skills so that the teachers can engage their students in authentic tasks. The instructors use inquiry-based strategies throughout the trainings in order to model the methods for the participants. Teachers are asked to brainstorm, solve authentic problems, map a unit of study, ask higher order thinking questions, make inferences and comparisons, draw conclusions and synthesize knowledge. This inquiry-based instructional model is an integrated approach that enables teachers to effectively deliver content by engaging students and helping them to read the content related materials. The reading instruction is embedded in the teaching and learning events, and therefore also in the overall goals and objectives of the instruction. This is a comprehensive approach to improving student learning utilizing research-based best practices throughout instruction.

In this model, teachers focus on content by developing appropriate student learning outcomes based on the Illinois Content Learning Goals and Standards and teaching and learning events tied directly to those outcomes. The teachers develop and implement inquiry-based units, infused with reading and instructional strategies that enable their students to apply higher order thinking skills (HOTS) to develop conceptual understandings of the content rather than just learning factual information using lower order thinking skills (LOTS). The teacher is trained in the role of a facilitator allowing students to take an active role in learning through the use of collaborative groups. Finally, teachers are trained in how to evaluate student artifacts in order to assess the effectiveness of the instruction and how to use that data to modify practice.

This study extends the understanding of the effects of reading comprehension instructional strategies embedded into an inquiry-based technology infused curriculum. The relationships are examined with a mixed regression model that allows for individual students and time of testing to be treated as random variables. The implementation strategies to address the goals are targeted at the student and teacher level, creating a readiness to begin and sustain the reforms.

Methods

Evaluation Model

The model used to evaluate the effectiveness of this 3-year project has three major components.

1) Random assignment of participating teachers to staggered-starting groups (Slavin, 2002).

2) Multiple measures to establish the internal validity and implementation level in the classroom (Breithaupt, 2000; Christensen, Griffin, & Knezek, 2001; Larsen, Mayer, Kight, & Golson, 1998; Mills, 1999).

3) Multiple measures of student outcomes (Ruiz-Primo, Shavelson, Hamilton, & Klein, 2002).

Participants

There are 381 teachers from forty-eight public schools and districts completing the training. Forty-two schools and districts administered Iowa Test of Basic Skills to students. These analyses include data for 212 teachers, twenty-seven schools, and 3,639 students in grades one through eight.

Data Analysis Plan for ITS REAL Evaluation

1) Pre/post comparison of teacher instructional strategy integration and technology literacy

2) Longitudinal analysis of student achievement data using regression analysis of predictors of student achievement to understand variability in student performance. Composite strategy and technology integration scores are generated using factor analysis.

Data Sources

Iowa Test of Basic Skills

Analyses for student achievement utilizes NCE scores. ITBS is suitable for students in grades K-8. Of the 84 reliability coefficients (internal consistency) reported for the various subtests, only 6 are in the .70s; the others are in the .80s and .90s.

SkillCheck

Teacher technology literacy is measured using SkillCheck, an online performance-based assessment. The validity tests completed for SkillCheck indicate concurrent validity correlation of .64 ($p<.003$) between SkillCheck test score and job performance. Alpha reliability of .74 and split half reliability of .80 were reported.

Face-to-Face Teacher Technology Proficiency

Teachers complete a face-to-face performance assessment of technology skills at their Regional Offices of Education service center.

Nextsteps ToolKit

Teachers report their levels of technology integration, use of inquiry, and comfort levels using different technologies in the Illinois Nextsteps Toolkit, an online survey available to all Illinois schools. Content and face validity are established through the process and the alignment of the items with Illinois learning standards and NETS.

Concerns Based Adoption Model

Measures of the intervention in the classroom include levels of use CBAM (Concerns Based Adoption Model; Hord, Rutherford, Huling-Ausin, & Hall, 1987; Loucks-Horsley, 1996) survey of use of inquiry, reading, writing, math, and technology integration strategies.

Teacher Implementation Logs

During the implementation of inquiry units created in the training, teachers complete weekly implementation logs describing their implementation of the unit. Units created by participating teachers are rated (by multiple raters) for consistency with inquiry, reading, writing, math, and technology standards.

MTIMMS Modified Observation Tool

A modified TIMSS survey was adapted for use with wireless pocket PCs. The median rating for each section for each rater in the reliability study was calculated and the average percent consensus across the one hundred six (106) teachers was computed for reliability. NOTE: there were several rating teams observing the one hundred six teachers. It consists of five sections related to students' roles, interaction, student engagement, cognitive activity, and student technology interaction. Raters completed the observations in five minute intervals for up to ten intervals. The median rating for each section for each rater in the reliability study was calculated and the average percent consensus across the one hundred six (106) teachers was computed for reliability. NOTE: there were several rating teams observing the one hundred six teachers. The average consensus across the categories was 83.1%.

Rating Category	Average Inter-Rater Percent Consensus*
Cognitive Activity	80
Student Engagement	76
Interaction	87
Student Role	91
Student Technology Interaction	82

*Based on the median rating across 10 intervals

Raters in the reliability study also completed global ratings of general technology use for the twenty eight teachers for general technology integration, topic integration, technology complexity, and teacher technology proficiency. The average percent consensus across the categories was 87.8%.

Rating Category	Average Inter-Rater Percent Consensus
Classroom Management	91
Teacher Proficiency	85
Technology Complexity	86
Topic Integration	86
General Technology Integration	91

Results

Pre/post comparison of teacher technology integration and literacy

Change in Strategy Use

Teachers showed clear increases in strategy use from summer 2003 to summer 2004 across all five subscales. For IBL and Reading, teachers increased their use of strategies from the learning stage to the occasional use stage (see Figure 1).

Change in Technology Proficiency

Teachers show clear evidence of improvement in technology proficiency in digital literacy, word processing, and internet browser skills (see Table 3 through Table 8). In addition, seventy-eight (78) percent (n=114 out of 147) teachers passed a face-to-face performance based checklist of minimum technology proficiency skills (first wave of trained teachers).

Change in IBL and Technology Strategy Use

Implementation of units and strategies are reported through observation as well as weekly logs completed by the teachers.

Learning Activities

Observers rated the cognitive activities they observed as more often (47%) applied procedural knowledge (rather than receipt of knowledge) and just over 1/3 of the observations are described as knowledge construction (35%; see Figure 2). Most activities are rated as highly engaging for students (71%, see

Figure 3). More (44%) of the interactions observed are a balance of student-teacher than student led or completely teacher led (see Figure 4). Finally, 85% of the activities rated the student role as active or co-constructor of meaning as opposed to passive or requiring little response (see Figure 5)

Use of Technology

About a quarter of the tasks observed are highly prescriptive technology integration for the students and the same percentage of tasks are judged to allow students to guide and shape their own learning (see Figure 6). Almost half of the topics are considered to be only partially integrated with the technology while about 30% are judged to be fully integrated (see Figure 7). Just over half of the observations indicate a moderately complex use of technology while over one-third are rated simple uses of technology (see Figure 8). Finally, more teachers are judged to be moderately technology proficient (58%) then advanced (25%) or novice (6%; see Figure 9).

Student Achievement

Data from six tested models are presented (see Table 7). The adopted model includes estimates for the year students entered the grant (Year 1, Year 2, or Year 3; fixed effect), composite reading and strategy implementation for 2003-2004 and 2004-2005, and an interaction between start year and strategy implementation. Plots of residuals with predicted values indicate the model is tenable. Model fit is determined by comparisons of both information criteria (-2 Restricted Log Liklihood, Akaike's Information Criterion, and Schwarz's Bayesian Criterion) as well as decreases in repeated measures variance with the new model. Parameter estimates (see Table 9) indicate reading and IBL strategies use variables are related to changes in reading total scores, with reading strategies showing positive influences and IBL strategies showing slightly negative influences on final scores. In Figure 10 and Figure 11, a few trends are apparent. First, the groups are not equal at the initial start wave, with Start Year 1 and 2 students scoring higher than Start Year 3 students. Second, comparing actual versus predicted students' scores shows the influence of the variation in teachers' strategy use on understanding students' progress. When teachers' use of IBL and Reading strategies are interacted with start year, the predicted scores show a steeper increase for Start Year 1 and 3 students in the last year of the grant and little effect on Start Year 2 students' scores. These changes correspond with the levels of strategy use for Start Year 1, 2, and 3 teachers reported in implementation logs (see Figure 12 to Figure 15). Changes across all groups across the three waves of data highlight the importance of multiple waves of data for detecting lasting patterns in achievement.

Limitations

Missing data are undoubtedly the most striking weakness in this study. Of the forty-eight participating schools, only forty-two districts collected ITBS data. Of these forty-two districts, only twenty-seven collected data in the spring, allowing for three waves of data that account for a baseline, one-year post, and two-year post. The missing data from teachers' logs as well as data not submitted by schools reduced the data for analyses by almost half.

However, the remaining data set is still quite large and useful for detecting preliminary evidence of the relationships between teachers implementation of inquiry based learning and explicit reading strategy instruction into the curriculum.

Several improvements are required to allow for stronger assertions about the program. First, a common assessment administered at the same time for all participating students would greatly improve the ability to analyze and detect patterns in the data. Second, missing data due to teachers' log omissions should be reduced as much as possible.

Conclusions

The progress of this project is clear. The I.T.'s. R.E.A.L. professional model changes teaching practices using inquiry-based strategies changing teacher instructional practices as well as supporting transformative technology integration. In addition, mixed model linear regression analyses indicate that these changes show potential for translating into measurable student achievement changes. Serious missing data issues attenuate the generalizeablity of the model results. Replication of these results is needed to more strongly assert the role of inquiry based learning, reading strategies, and transformative technology integration in student reading achievement. The I.t.'s R.E.A.L. model provides several positive advances in managing data collection, especially for tracking the implementation of curriculum in schools, for large-scale studies.

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Figure 1. Change in strategy use

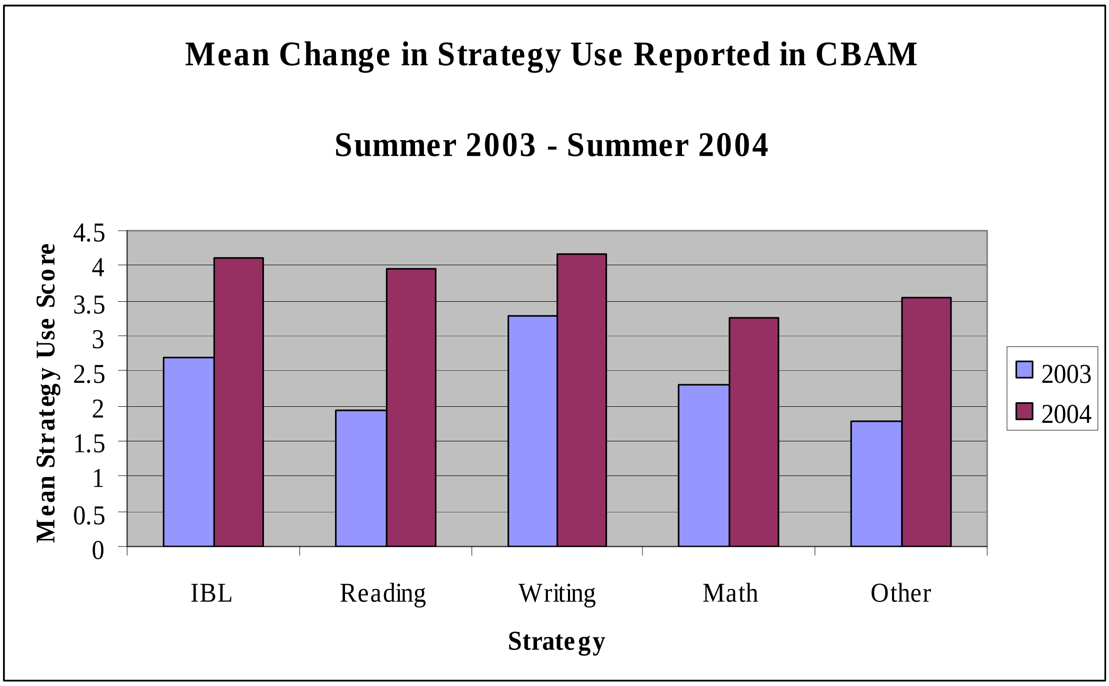

Table 1. SkillCheck – Digital Literacy - Beginner

t-Test: Paired Two Sample for Means

Beginner - Digital Literacy		
	Pre	*Post*
Mean	48.95652	69.55072
Variance	205.3657	146.6922
Observations	69	69
Pearson Correlation	0.452245	
Hypothesized Mean Difference	0	
df	68	
t Stat	-12.2483	
P(T<=t) one-tail	3.61E-19	
t Critical one-tail	1.667572	
P(T<=t) two-tail	7.23E-19	
t Critical two-tail	1.995469	

Table 2. SkillCheck – Digital Literacy - Intermediate

t-Test: Paired Two Sample for Means

Intermediate - Digital Literacy		
	Pre	*Post*
Mean	36.82609	57.97101
Variance	284.7046	347.2344
Observations	69	69
Pearson Correlation	0.477803	
Hypothesized Mean Difference	0	
df	68	
t Stat	-9.64724	
P(T<=t) one-tail	1.16E-14	
t Critical one-tail	1.667572	
P(T<=t) two-tail	2.32E-14	
t Critical two-tail	1.995469	

Table 3. SkillCheck – IE5 - Beginner

t-Test: Paired Two Sample for Means

Beginner IE5		
	Pre	*Post*
Mean	68.26923	78.80769
Variance	274.2046	86.32154
Observations	26	26
Pearson Correlation	0.382021	
Hypothesized Mean Difference	0	
df	25	
t Stat	-3.44731	
P(T<=t) one-tail	0.001007	
t Critical one-tail	1.708141	
P(T<=t) two-tail	0.002014	
t Critical two-tail	2.059539	

Table 4. SkillCheck – IE5 - Intermediate

t-Test: Paired Two Sample for Means

Intermediate - IE5		
	Pre	*Post*
Mean	33.07692	54.80769
Variance	242.5538	163.9215
Observations	26	26
Pearson Correlation	0.322848	
Hypothesized Mean Difference	0	
df	25	
t Stat	-6.64897	
P(T<=t) one-tail	2.87E-07	
t Critical one-tail	1.708141	
P(T<=t) two-tail	5.75E-07	
t Critical two-tail	2.059539	

Table 5. SkillCheck – Word2000 - Beginner

t-Test: Paired Two Sample for Means

Beginner - Word 2000		
	Pre	*Post*
Mean	65.83582	76.40299
Variance	339.7454	220.0321
Observations	67	67
Pearson Correlation	0.407277	
Hypothesized Mean Difference	0	
df	66	
t Stat	-4.71126	
P(T<=t) one-tail	6.56E-06	
t Critical one-tail	1.668271	
P(T<=t) two-tail	1.31E-05	
t Critical two-tail	1.996564	

Table 6. SkillCheck – Word2000 - Intermediate

t-Test: Paired Two Sample for Means

Intermediate - Word 2000		
	Pre	*Post*
Mean	38.23881	63.83582
Variance	459.6694	552.6545
Observations	67	67
Pearson Correlation	0.286111	
Hypothesized Mean Difference	0	
df	66	
t Stat	-7.78725	
P(T<=t) one-tail	3.18E-11	
t Critical one-tail	1.668271	
P(T<=t) two-tail	6.36E-11	
t Critical two-tail	1.996564	

Figure 2. Cognitive Activity Median

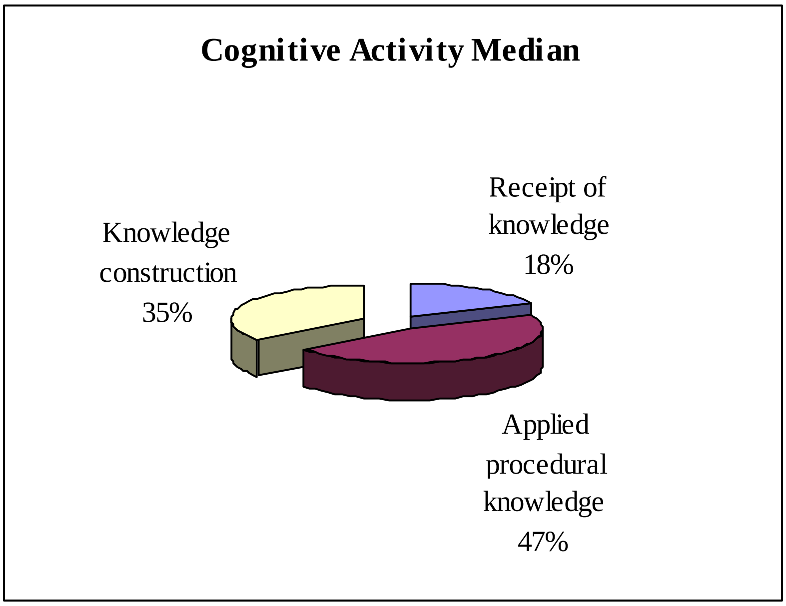

Figure 3. Student Engagement Median

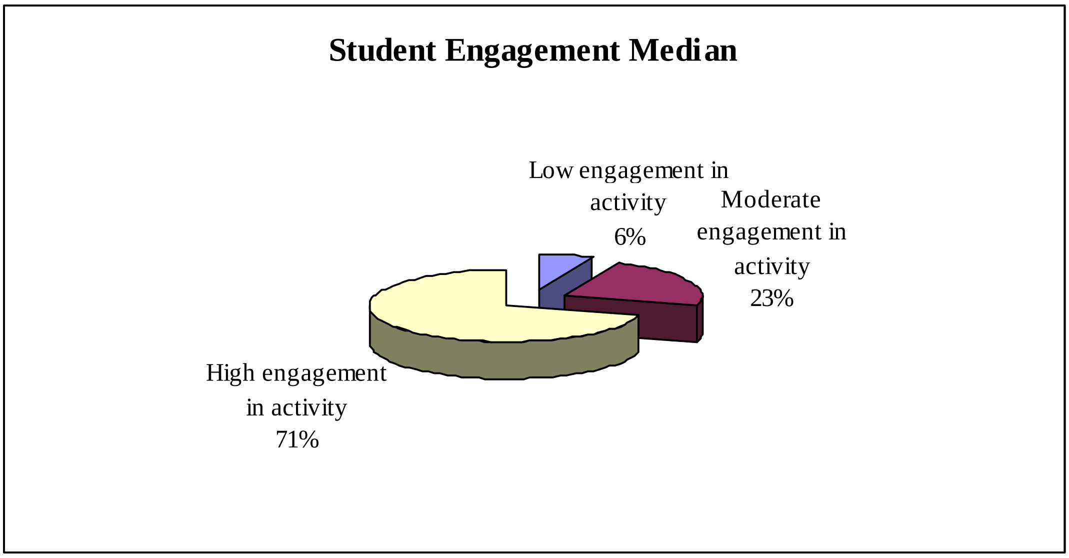

Figure 4. Interaction Median

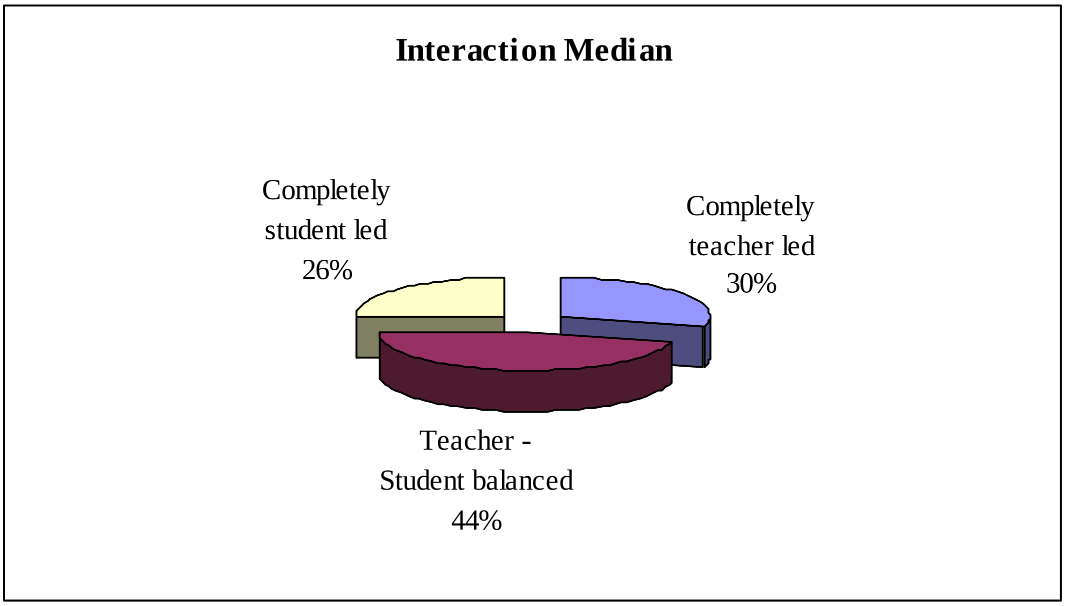

Figure 5. Student Role Median

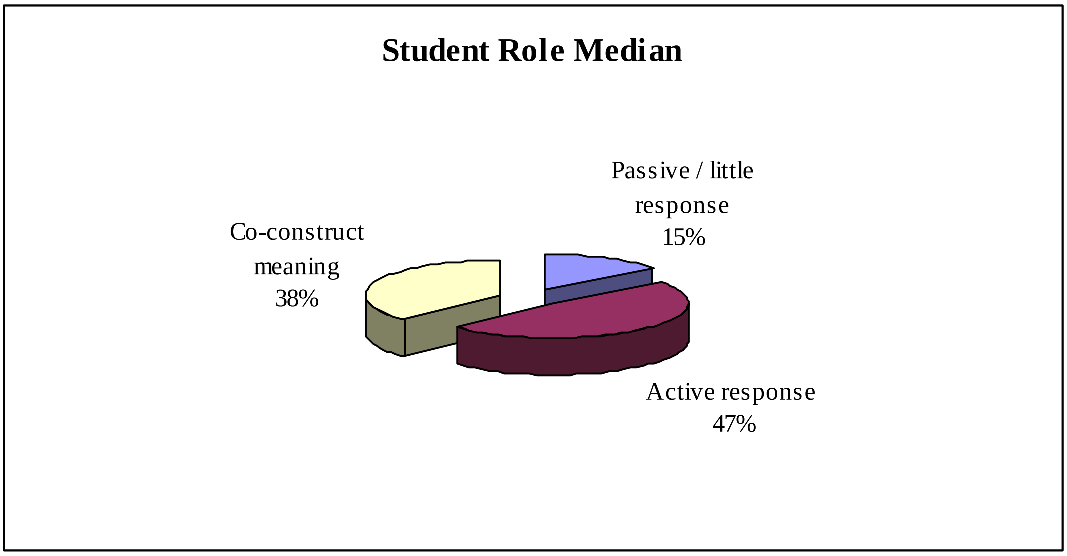

Figure 6. Student Technology Integration Median

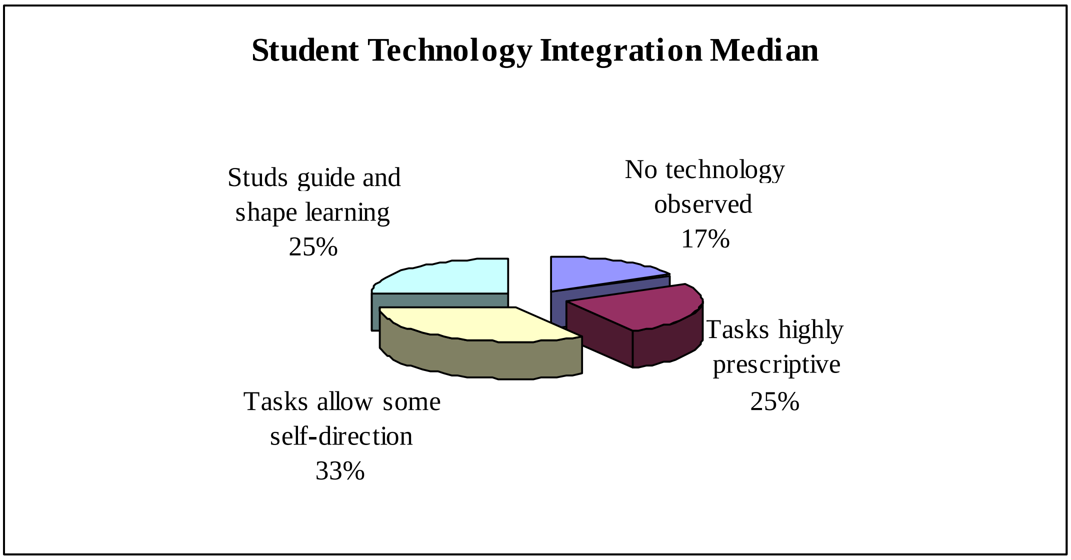

Figure 7. General Topic Integration Median

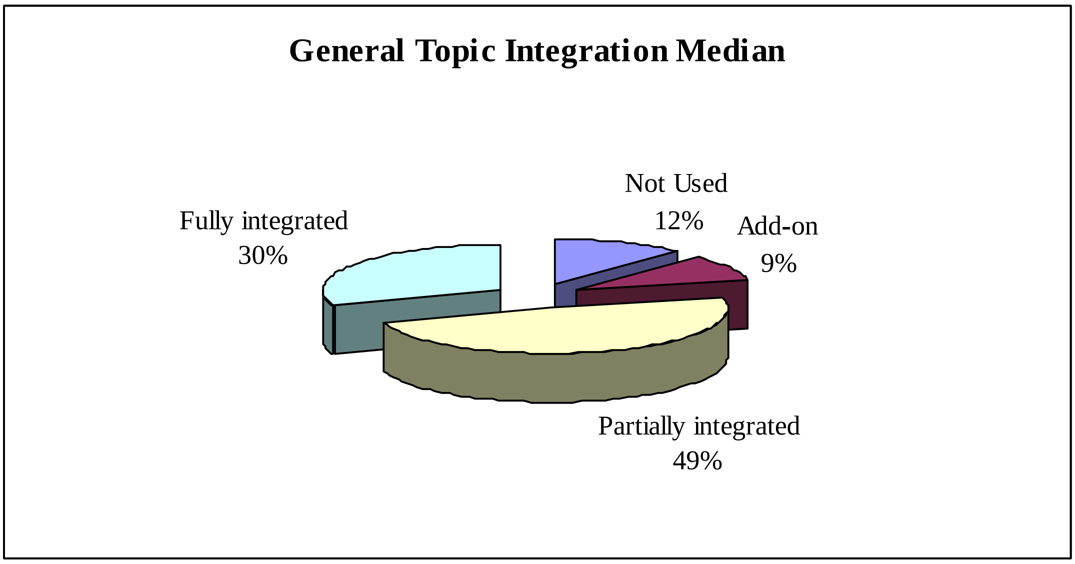

Figure 8. Technology Complexity Median

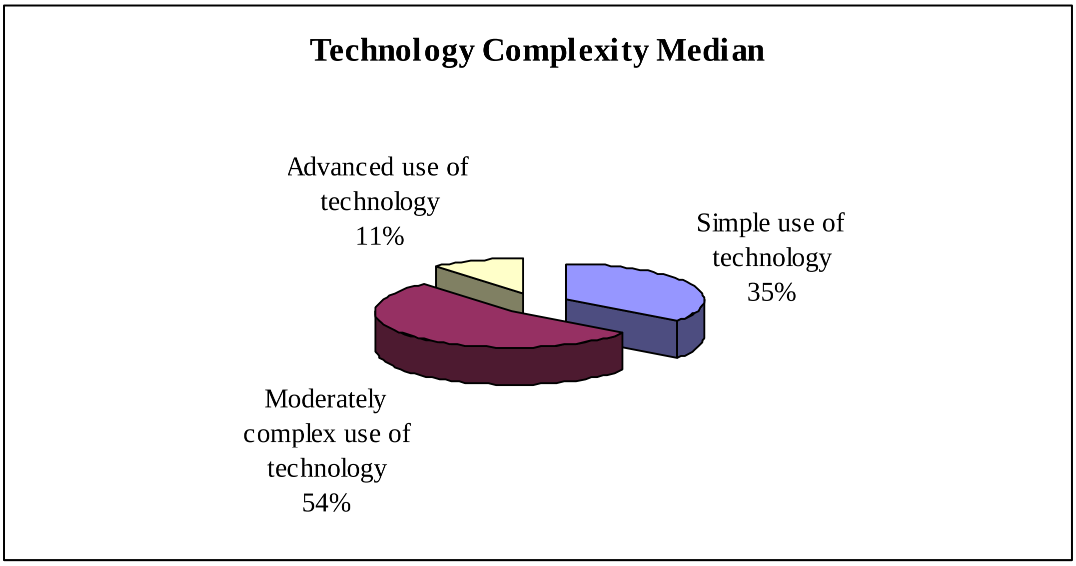

Figure 9. Teacher Proficiency Median

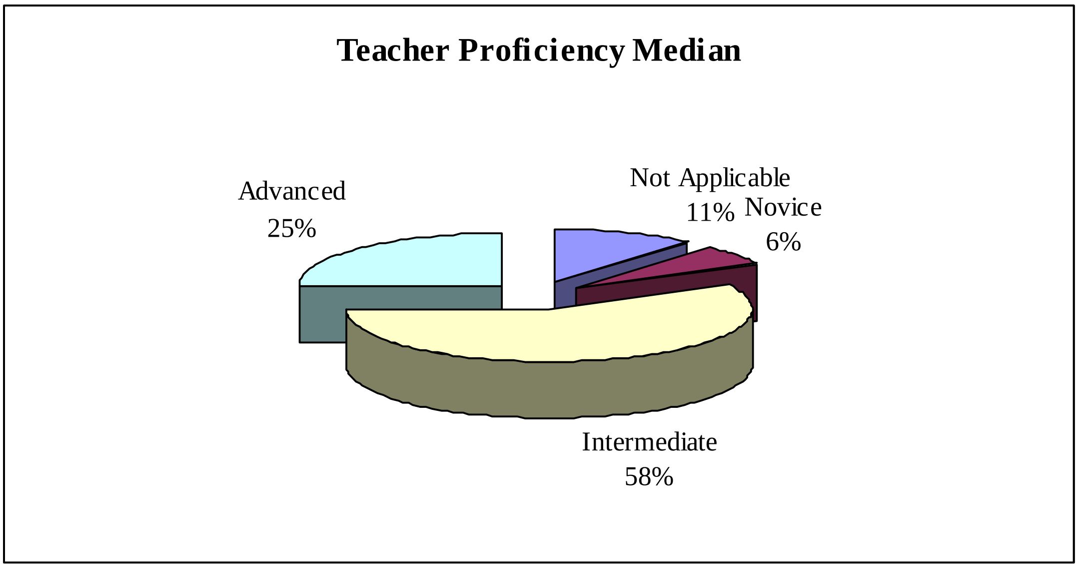

Table 7. Mixed regression model summary

Model Summary*	-2LL	AIC	BIC
Start Year	31406.782	31408.782	31414.957
Start Year, IBL (03-04), Reading (03-04)	28480.433	28482.433	28488.512
Start Year, IBL (03-04), Reading (03-04), IBL (04-05), Reading (04-05)	28463.966	28465.966	28472.044
Start Year, IBL (03-04), Reading (03-04), IBL (04-05), Reading (04-05), Start Year*IBL/Reading (03-04)	28416.180	28418.180	28424.257
Start Year, IBL (03-04), Reading (03-04), IBL (04-05), Reading (04-05), Start Year*IBL/Reading (03-04), Start Year * IBL/Reading (04-05)	28403.406	28405.406	28411.483

*Random effects: Intercept, test time (Spring 2003, Spring 2004, Spring 2005), teacher

**Covariance Structure=Scaled Identity

Table 8. Tests of fixed effects

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	3218.000	7948.558	.000
Start_Wave	1	3218.000	12.038	.001
IBL(03_04)	1	3218.000	6.239	.013
Reading(03_04)	1	3218.000	9.947	.002
IBL(04_05)	1	3218.000	.420	.517
Reading(04_05)	1	3218.000	.802	.371
Reading(03_04)(Start_Wave)	1	3218.000	3.414	.065
IBL(03_04) (Start_Wave)	1	3218.000	.735	.391
Reading(04_05) (Start_Wave)	2	3218.000	5.572	.004
IBL(04_05) (Start_Wave)	2	3218.000	14.981	.000

a Dependent Variable: Reading Total Score.

Table 9. Regression coefficiencts of fixed effects

Estimates of Fixed Effects(b)

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	58.04201	2.249822	3218	25.79848	1.5E-133	53.63078	62.45324
[Start Wave=1]	0.144415	2.439613	3218	0.059196	0.9528	-4.63894	4.927768
[Start Wave=2]	-4.21474	1.99403	3218	-2.11368	0.034619	-8.12444	-0.30505
[Start Wave=3]	0	0	.	.	.	.	.
IBL(03-04)	-6.448	3.049669	3218	-2.11433	0.034564	-12.4275	-0.46851
Reading (03-04)	10.36869	3.498061	3218	2.964124	0.003058	3.510033	17.22734
IBL(04-05)	-4.90756	1.064838	3218	-4.60874	4.21E-06	-6.99539	-2.81973
Reading (04-05)	4.469362	1.333258	3218	3.35221	0.000811	1.855241	7.083484
Reading (03-04)([Start Wave=1])	-7.66095	4.14605	3218	-1.84777	0.064727	-15.7901	0.468211
Reading (03-04)([Start Wave=2])	0	0	.	.	.	.	.
Reading (03-04)([Start Wave=3])	0	0	.	.	.	.	.
IBL(03-04)([Start Wave=1])	3.295493	3.843432	3218	0.857435	0.391268	-4.24033	10.83131
IBL(03-04)([Start Wave=2])	0	0	.	.	.	.	.
IBL(03-04)([Start Wave=3])	0	0	.	.	.	.	.
Reading (04-05)([Start Wave=1])	-3.15268	2.833431	3218	-1.11267	0.265932	-8.70819	2.402833
Reading (04-05)([Start Wave=2])	-7.28303	2.184168	3218	-3.33447	0.000864	-11.5655	-3.00053
Reading (04-05)([Start Wave=3])	0	0	.	.	.	.	.
IBL(04-05)([Start Wave=1])	6.253253	2.315067	3218	2.701111	0.006947	1.714097	10.79241
IBL(04-05)([Start Wave=2])	10.30531	1.949258	3218	5.286788	1.33E-07	6.483401	14.12723
IBL(04-05)([Start Wave=3])	0	0	.	.	.	.	.

aThis parameter is set to zero because it is redundant.

bDependent Variable: Reading_Total_Score.

Figure 10. Predicted student reading scores across cohort groups

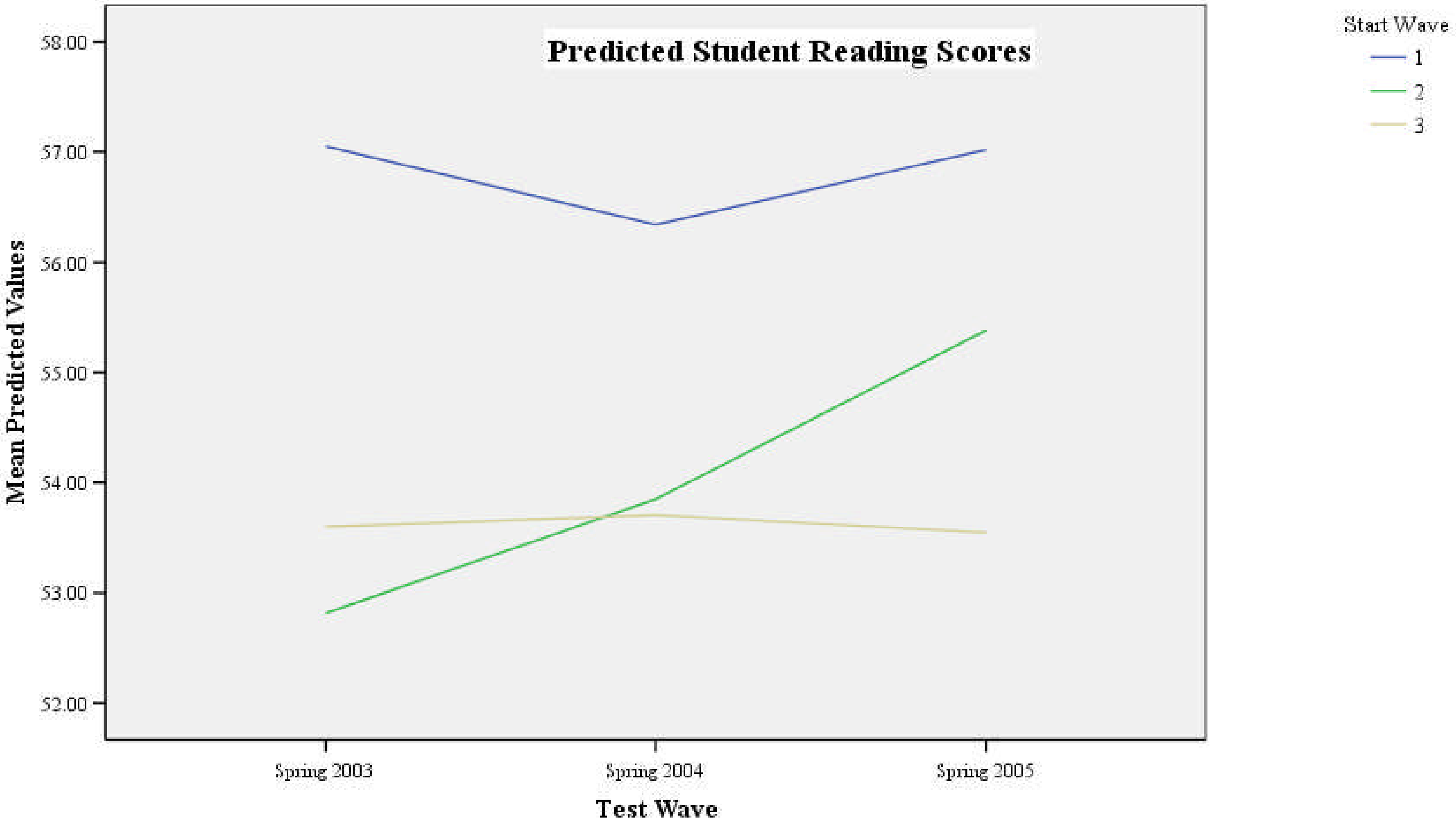

Figure 11. Actual student reading scores across cohort groups

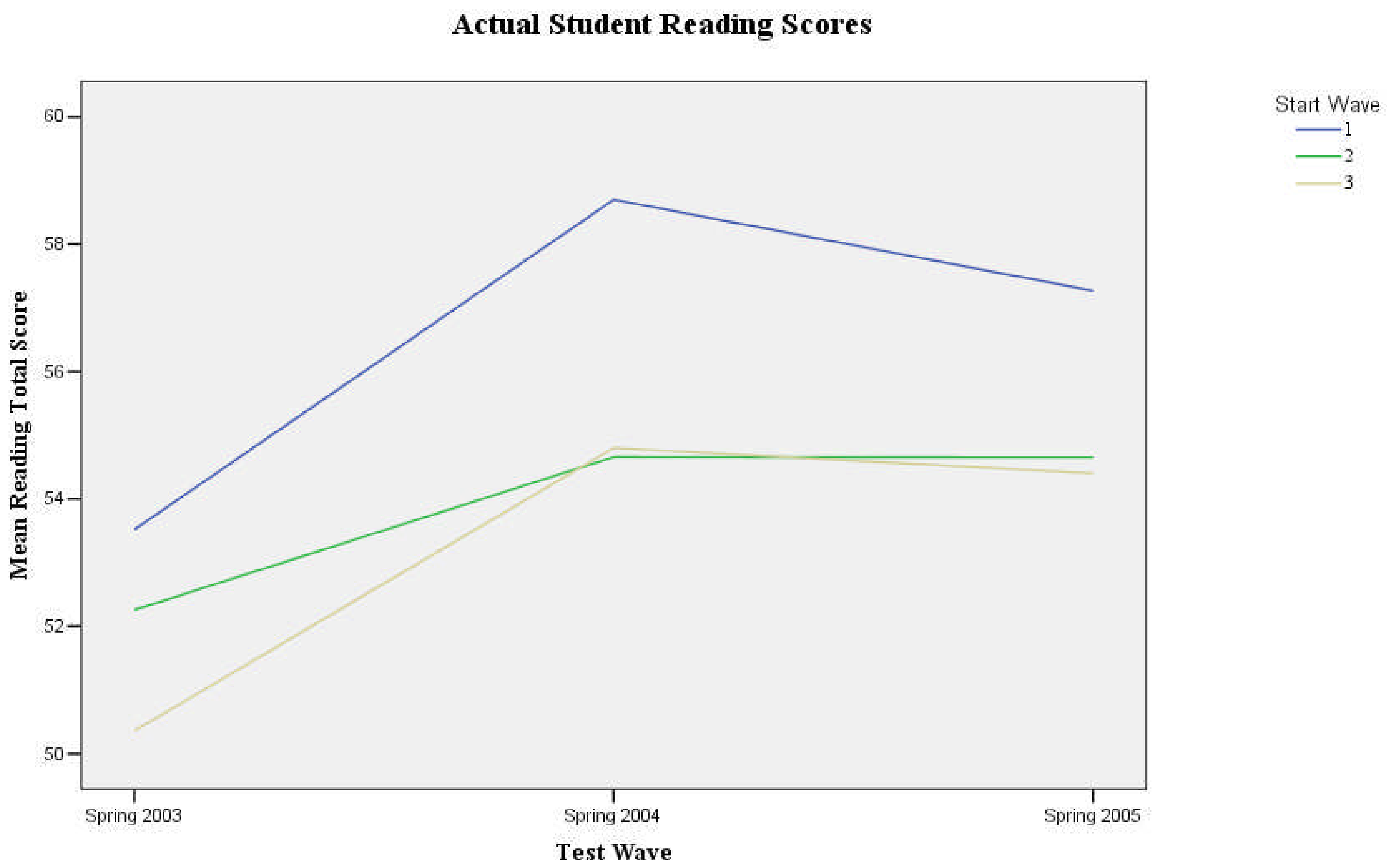

Figure 12. IBL Strategy Use 2003-2004

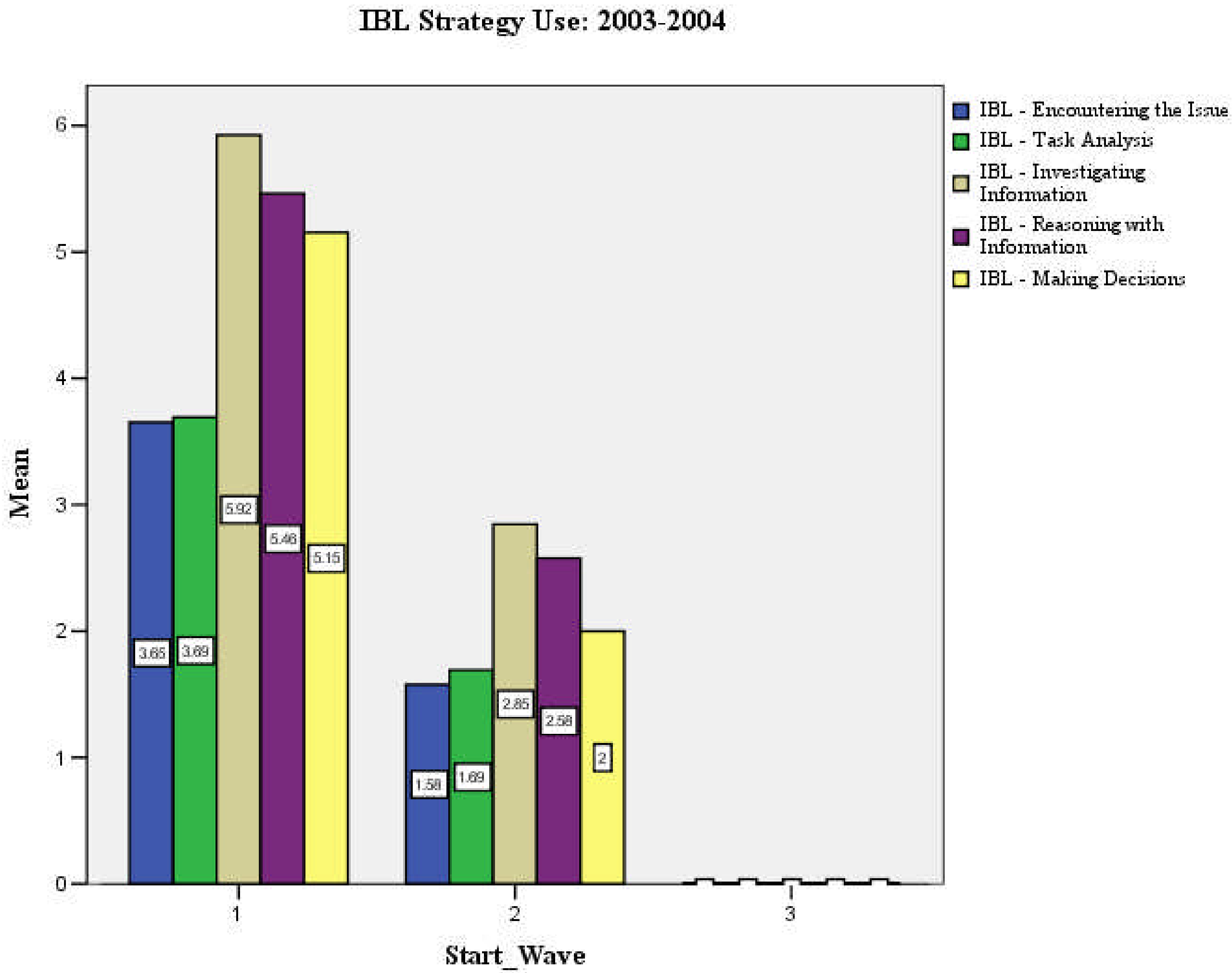

Figure 13. Reading Strategy Use 2003-2004

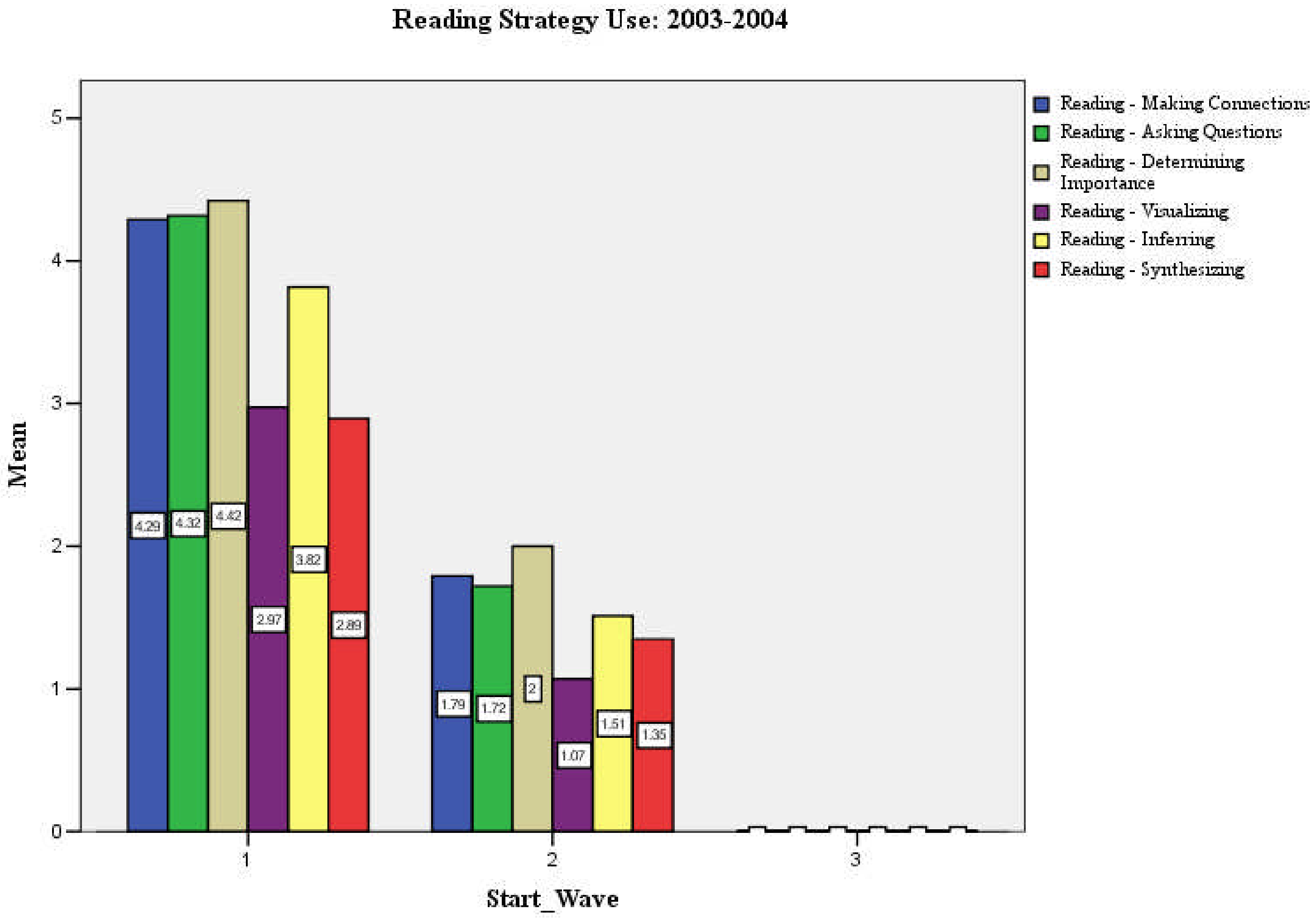

Figure 14. IBL Strategy Use 2004-2005

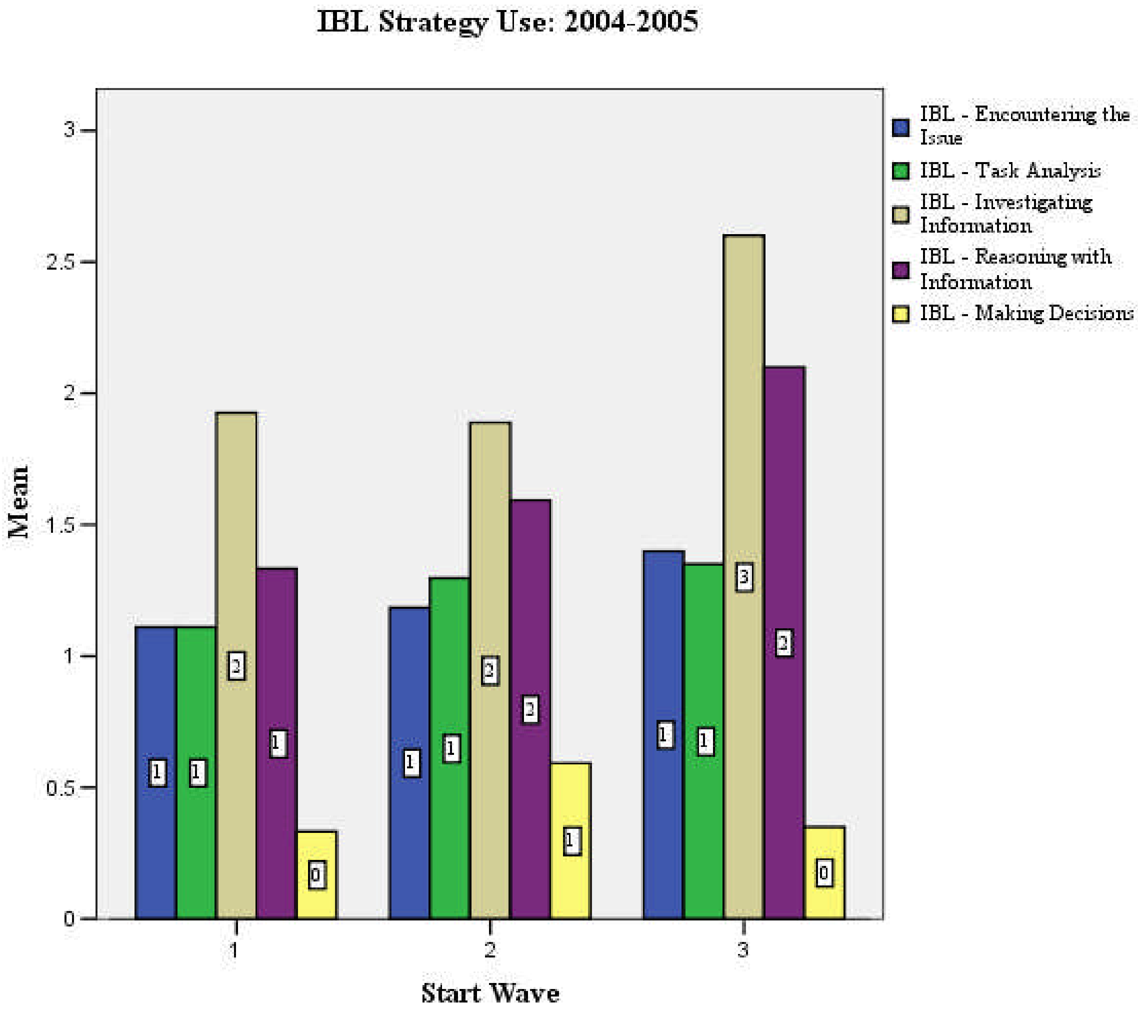

Figure 15. Reading Strategy Use 2004-2005