Anytime, Anywhere Learning

Final Evaluation Report of the Laptop Program: Year 3

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December 2003

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EXECUTIVE SUMMARY

This report summarizes the results of an evaluation study of the Year 3 implementation of the Anytime, Anywhere Learning (laptop program) implemented in Walled Lake Consolidated Schools (WLCS), Michigan. The overall purpose of the Year 1 (Ross, Lowther, Plants, & Morrison, 2000) and Year 2 evaluations (Ross, Lowther, & Morrison, 2001) was to determine the educational impact of providing 5th, 6th, and 7th grade students with access to laptop computers with regard to classroom learning activities, technology usage, writing achievement and problem-solving ability. The purpose of the Year 3 study was to determine the effectiveness of providing 5th grade students with access to laptop computers and if differences occur based on the amount of time (24 hours per day vs. class-time only) and/or type of access (personal laptop vs. laptop on school mobile cart) to the computers.

WLCS laptop program. The WLCS laptop program is based on the Anytime, Anywhere Learning (AAL) program (AAL, 2000), which has been in schools since 1996 and has impacted more than 100,000 students and teachers. The goal of the AAL program is to provide students the knowledge, skills and tools to learn anytime and anywhere. The laptop classrooms were equipped with wireless access to the Internet and printers. The program provided Year 1 students and parents the opportunity to receive training on basic computer skills. Year 2 and 3 students and parents received a software tutorial for learning basic computer skills.

Year 1 of the laptop program began with 26 teachers who taught grades 5 and 6. These teachers received ten full days of professional development prior to the 1999-2000 academic year and six one-half day sessions during the year. For Year 2, the 5th and 6th grade students took their laptops with them to the 6th and 7th grades and 8 new 5th grade laptop classrooms were added. Year 3 focused on 5th grade classes. Teachers new to the program received one-on-one training from a previously trained laptop teacher who was hired as a full-time facilitator of the laptop program. As in Year 1 and 2, the Year 3 training was based on the iNtegrating Technology for inQuiry (NTeQ) model (Morrison & Lowther, 2002), which provides teachers a framework to develop problem-based lessons that utilize real-world resources, student collaboration, and the use of computer tools to reach solutions. The lessons are typically structured around projects that engage the students in critically examining community and global issues, while strengthening student research and writing skills.

In the Year 1 evaluation, the findings showed that Laptop students were using computers more extensively and skillfully in their classrooms than were non-Laptop students. Importantly, usage of the computers was significantly more meaningfully integrated with curriculum in Laptop than in non-laptop classrooms. Laptop students also significantly surpassed non-Laptop students in writing skills, an outcome considered attributable to the increased opportunities to practice writing via the computer. In contrast to the Year 1 evaluation, the Year 2 study revealed relatively few differences in teaching methods between laptop and Computer-Extended (CE) classrooms (with 1 to 5+ computers available for student use), perhaps due to the CE classes also having NTeQ-trained teachers and enhanced technology resources. However, consistent across Year 1 and Year 2 studies was the laptop students' more frequent usage of the computer as a learning tool – specifically, greater use of word-processing and CD referencing software. Also consistent with Year 1 results were the differences in student achievement as seen in laptop students demonstrating superior writing and problem-solving skills as compared to the CE students.

RESEARCH QUESTIONS

The Year 3 evaluation of the laptop program was structured around six primary research questions that focused on classroom practices, student achievement, and student behaviors and attitudes. Also of interest was the reaction and support of teachers involved with the laptop program or those who used mobile laptop carts (cart). The research questions are listed below:

- What differences emerge in teaching strategies used during a computer-supported lesson in laptop versus cart classrooms?
- Do laptop students differ from cart students in their writing skills?
- Do laptop students differ from cart students in their approach to problem solving?
- Do laptop students differ from cart students in their mathematics, science, and social studies achievement at the 5th grade level?
- How do students perceive the use and access of laptop computers?
- What do teachers perceive as the benefits and problems of integrating technology in laptop vs. cart classrooms?

EVALUATION DESIGN AND MEASURES

The evaluation period extended from September 2002 through May 2003. The evaluation design was based on both quantitative and qualitative data collected from 5th grade students and teachers involved either with the laptop program or in classrooms using mobile laptop carts from which each student was provided a laptop computer. Participants came from six schools within WLCS. Comparative analyses were completed for teaching activities and learning outcomes and descriptive analyses were completed for student and teacher reactions to the laptop program (laptop) or using mobile laptop carts (cart).

Classroom Observation Measures. Three separate observations measures were used to collect observation data: The *School Observation Measure* (*SOM*©), the *Survey of Computer Use* (*SCU*©), and the *Rubric for Student-Centered Activities (RSCA*©*).* *SOM* was based on 60 continuous minutes of observation, divided into about four 15-minute segments. These four observation periods were then summarized on one *SOM* Data Summary form. *SCU* and *RSCA* were completed as part of the 60-minute observation sessions. A total of 19 classroom observations were conducted, with 19 in laptop classrooms and 9 in cart classrooms.

Achievement Measures. The WLCS's *Writing Scoring Guide* was used to assess prompted writing samples from laptop and cart students. For this study, 132 laptop and 140 cart writing samples were randomly selected from those taken for the district test for comparative analysis. The District's assessment examines four dimensions of writing: Ideas and Content, Organization, Style, and Conventions.

To assess the ability of students to comprehend problems and formulate solutions, the problem-solving task devised for the Year 2 study was utilized. The task involved giving students a problem situation, and instructing them to describe different aspects of how they would solve the problem. Assessment components consisted of "Understands problem," "Identifies what is known about the problem," "Identifies what needs to be known to solve the problem," "Determines how the data need to be manipulated to solve the problem," "Describes use of technology," "Describes how to present findings," and "Collaborative learning." A total of 138 laptop and 134 cart students completed the problem-solving task.

Student achievement was assessed with scores from the district administered test to measure the following Michigan Curriculum Standards and Benchmarks: mathematics (1-4), science, and social studies. The students' fourth grade (pre-laptop) MEAP mathematics total raw scores from 2001-2002 were used as a covariate to control for initial differences among students when making program comparisons.

The student and teacher surveys primarily focused on four areas: (1) to what extent the computers had a personal impact (increased skills – research, computer, and learning), (2) to what extent the computers impacted students, (3) the patterns of student usage of the laptops, and (4) the barriers to using the laptops. The final data set includes: 366 student surveys (171 laptop; 195 cart) and 12 teacher surveys (9 laptop; 3 cart).

RESULTS

Classroom Observations

SOM©. The SOM data revealed relatively few differences in teaching methods between laptop and cart classes. This is not surprising considering that both the laptop and cart teachers were trained in the NTeQ model and had substantial access to computers for instructional purposes. Thus, both groups of teachers were similar in the degree to which they acted as coach/facilitators, engaged students in sustained writing and the use of computers as a learning tool or resource. Though not significant, the laptop students were engaged in more independent inquiry research as compared to the cart students and were more frequently in classes with a high level of academically focused class time.

RSCA©. Comparisons were made between the laptop classes and the cart classes on the seven RSCA items using the independent t-test. The results indicated that there were no statistical significances between the two groups of classes. However, descriptive analysis revealed that for the laptop classes, project-based learning (M = 4.00) was considered the most meaningful, while the lowest mean score (M = 1.67) was for students as producers of knowledge. For the cart classes, independent inquiry/research was the most meaningful (M = 2.20) and the lowest mean score was higher-level questioning strategies (M = 1.00). Notably, three of the seven strategies, (experiential, hands-on learning and student discussion for both classes, and project-based learning for the cart classes) were not observed.

SCU©. Although no significant differences were found between the laptop and cart observations, data from the SCU revealed moderate advantages for the laptop over the cart students. For example, although students in both the laptop and cart classes primarily worked alone on up-to-date, Internet-connected computers, the majority of the laptop students were considered to have very good computer literacy and keyboarding skills as compared to only one third or less of the cart students. Word processing was the most frequently used software by both groups; however laptop students more frequently used the Internet than the cart students. Across both groups, language arts was most frequently the subject area of the computer activities, yet, computers were used to a lesser degree for social studies, science, and mathematics. Regarding the meaningfulness of the computer activities, most were considered to be somewhat meaningful, with the laptop students more frequently engaging in more meaningful activities than the cart students.

Writing Performance

Mean performance scores for laptop and cart students were analyzed by group via a one-way multivariate analysis of variance (MANOVA) with the four dimension scores serving as the dependent variables. The MANOVA yielded a highly significant difference, $F(4, 267) = 9.16$, $p = .001$. Follow-up analyses showed significant advantages for the laptop over cart students on all four components, as seen in effect sizes ranging from +0.33 to +0.63. Effects of this magnitude represent strong and educationally important impacts (see Cohen, 1988).

Problem-Solving Performance

To determine if significant differences existed between the groups, a MANOVA was conducted to compare the laptop and cart problem-solving scores. The results depicted a significant multivariate effect, $F(7, 264) = 4.60$, $p < .000$. Follow-up analyses of univariate effects revealed that the laptop scores were significantly higher on five of the seven components: use of technology (laptop $M = 1.69$; cart $M = 1.31$), what is known (laptop $M = 1.47$; cart $M = 1.26$), presents findings (laptop $M = 1.56$; cart $M = 1.37$), understands problem (laptop $M = 1.68$; cart $M = 1.50$), and manipulates data (laptop $M = 1.89$; cart $M = 1.72$). Upon examination of the resulting effect sizes of the differences, the implied educational impact ranges from high for use of technology ($ES = +0.55$) to somewhat limited for manipulate data ($ES = +0.26$).

STUDENT ACHIEVEMENT

Mean raw scores (*M)*, and standard deviations (*SD*) were computed for mathematics (Benchmark 1-4), science, and social studies tests and the fourth grade (2001-2002) MEAP raw scores. Results from an independent *t*-test revealed that the laptop students 4^{th} grade mathematics MEAP scores were significantly higher than the scores for cart students ($t(431) = 4.51$, $p < 0.001$, $ES = .45$). In addition, the means for laptop students were directionally higher than the means of cart students on all tests. The MANCOVA yielded a significant overall program effect: $F(6, 245) = 5.67$, $p<.001$. However, the univariate ANOVAs conducted on each test produced a significant effect on Mathematics Benchmark 2 only, with the laptop students scoring significantly higher $F(1,250) = 20.99$, $p<.001$ than the cart students (laptop $M = 89.32$; cart $M = 77.83$). The effect size for this difference was $ES = +.44$, indicating a strong effect favoring the laptop group.

STUDENT REACTIONS

Although both groups indicated positive reactions to the personal impact of using laptop computers, laptop students were significantly more positive regarding increased computer skills, having more fun, being more interested in learning, and wishing to get better grades. The groups were also significantly different in all three categories of usage, with the laptop students indicating that they were much more likely to use their computers alone every day and to work in pairs several times a week. When looking at student laptop use by subject area, laptop students were significantly more likely than cart students to respond that they used laptops for language arts almost every day and for mathematics on a weekly basis. The laptop students were significantly more likely than cart students to use laptops for social studies, however to a lesser degree than for language arts. No significant differences between the groups emerged for science. Few difficulties related to student use of laptop computers were reported by either group, however, the laptop students indicated a higher level of confidence with regard to using the keyboard.

TEACHER REACTIONS

As a group, the teachers conveyed positive reactions about the benefits of students using laptops as a learning tool. However, the laptop teachers in general reported higher agreement than cart teachers that the use of laptops had increased their personal ability to use computers, to integrate student use of computers into lessons, and to use higher-level and project-based learning in the classroom. There was unanimous agreement that participation in the laptop program increased students' interest in learning, nevertheless the laptop teachers had greater agreement that the laptops helped to increase student writing and research skills, and the ability to work with other students. The majority of the laptop teachers also indicated the laptops had increased student performance/grades. There were no notable difficulties reported regarding student use of laptops in the classroom.

DISCUSSION

Results of this study suggest positive impacts of students using laptop computers as learning tools. However, students who had continuous access to the laptop computers had significant advantages over students who only had classroom access to laptops from a mobile laptop cart. These findings are discussed below in reference to the six primary research questions.

IS TEACHING DIFFERENT IN A LAPTOP VS. A CART CLASSROOM?

Year 3 results revealed no significant differences between teaching activities or computer use in the laptop vs. cart classes. The classroom observations revealed that both laptop and cart teachers acted as coach/facilitators, engaged students in sustained writing and the use of computers as a learning tool or resource. Though not significant, the laptop students were engaged in more independent inquiry research as compared to the cart students and were more frequently in classes with a high level of academically focused class time.

When examining student use of computers, the Year 3 data again revealed no significant differences between the laptop and cart classes. Both groups of students primarily worked alone on up-to-date, Internet-connected computers, however the computer skills of the laptop students were somewhat higher than the cart students. Word processing was the most frequently used software by both groups and language arts was most frequently the subject area of the computer activities. Regarding the meaningfulness of the computer activities, most were considered to be somewhat meaningful, with the laptop students more frequently engaging in more meaningful activities than the cart students.

In summary, the lack of difference in classroom practices in laptop vs. cart classes can most likely be attributed to two factors: both the laptop and cart teachers were trained in the NTeQ model and both groups had substantial access to computers for instructional purposes.

Thus, the teaching activities in both classes included non-traditional methodologies that integrated student use of computers as a tool to support meaningful learning. However, the following approaches often associated with best practices and improved student learning were infrequently observed in laptop and/or cart classes: cooperative learning, higher-level feedback and questioning, project-based learning, or integration of subject areas. It may be useful to provide additional professional development that reemphasizes the NTeQ Model, which targets these strategies to ensure students experience a well-rounded classroom environment that supports increased student achievement.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR WRITING SKILLS?

The Year 1 and 2 studies revealed that the laptop students demonstrated superior writing skills as compared to the control students. The results from the Year 3 study followed the same trend, with laptop students showing significant advantages over cart students on the four dimensions of Ideas and Content, Organization, Style, and Conventions. Although the Year 3 results reveal educationally important impacts, the effect sizes were directionally lower than those from Year 2 (Ideas and Content: Yr 2 = +90, Yr 3 = + 67; Organization: Yr 2 = +83, Yr 3 = +37; Style: Yr 2 = +94, Yr 3 = +34; Conventions: Yr 2 = +59, Yr 3 = + 33). Thus suggesting that students with continuous access to laptops have advantages over those who only use laptops during class, and even a greater advantage over students in classrooms limited to 5 or more computers to be shared by all students.

Although the observation data did not reveal significant differences in classroom practices, laptop students more frequently used word processing and the Internet for language arts activities and independent inquiry/research. In addition, a majority of the laptop students felt the computers had increased their interest in learning, made learning more fun, and increased their overall computer skills. Perhaps the above factors, along with 24-hour access to the laptops, contributed to overall writing ability of the laptop students.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR APPROACH TO PROBLEM SOLVING?

The Year 3 results showed the laptop students outperforming the control students on five of the seven problem-solving components. However, as with the writing test, there was a Year 2 to Year 3 decrease in the effect sizes of these differences. The Effect Sizes for Year 2 ranged from +. 38 to +.76, where as the Year 3 range was only +.26 to +.55.

Even though significant differences in classroom practices were not revealed, laptop students more frequently engaged in independent inquiry/research and more frequently used the Internet – both of which could perhaps enhance student's problem-solving performance (e.g., understanding a problem, identifying what is needed to solve the problem, how to use technology to solve the problem). The laptop students reported significantly more use of the laptop computers in mathematics and social studies – subject areas into which teachers might more easily integrate problem-based learning activities. They also indicated that they frequently engage in cooperative learning, which requires students to process and share information. These combined factors conceivably contributed to the laptop students' increased problem-solving ability, however further research with other students is needed.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR MATHEMATICS, SCIENCE, AND SOCIAL STUDIES ACHIEVEMENT AT THE 5TH GRADE LEVEL?

The analysis of achievement scores in mathematics (1-4), science and social studies revealed directionally higher means for laptop students as compared to the cart students. However, significant differences between the two groups only occurred on one measure, the Mathematics Benchmark 2 (Geometry and Measurement). This difference did have an

ES = +.44, indicating a moderate effect favoring the laptop group. Since use of the 4th grade MEAP scores as a covariate addressed the initial laptop student advantage, the difference is less likely to be attributed to the laptop students just being "better" students. Other possible factors could be that laptop students used the computers for mathematics activities more frequently than cart students. In addition, even though the classroom practices did not reveal significant differences between laptop and cart groups, the data reveal a pattern of more frequent use in the laptop classes of independent inquiry/research, higher-level instructional feedback, project-based learning, and draw/paint/graphics software. All of which, when combined and used over time, may result in students who are better able to understand geometry and measurement content as listed in state's curriculum mathematics standard II:

How do students perceive the use and access of laptop computers?

Both the laptop and cart students responded positively when asked about the benefits of using laptop computers for school-related activities. Both groups also indicated that they experienced very few difficulties or barriers to using the laptops in a classroom setting. However, significant differences emerged between the laptop students, who "own" the laptop and have continuous access to it and the cart students who use a school laptop from a mobile cart. For example, the laptop students were significantly more positive that using the laptop had increased their computer skills, made learning more fun and interesting, and provided incentives to get better grades. Personal ownership also seemed to influence the type of laptop usage that occurred during class time as the laptop students were much more likely to use their computers alone every day and to work in pairs several times a week. The subject areas of computer activities were also significantly different in laptop vs. cart classes. The laptop students responded that they used laptops for language arts almost every day and were more likely than cart students to use them for mathematics and social studies, however to a lesser degree than for language arts. No significant differences between the groups emerged for science. These results suggest student attitudes about the educational benefits of using laptops are positively influenced when they "own" a laptop as compared to using school computers stored on a mobile cart.

WHAT DO TEACHERS PERCEIVE AS THE BENEFITS AND PROBLEMS OF INTEGRATING TECHNOLOGY IN LAPTOP VS. CART CLASSROOMS?

Although only a small number of teacher surveys were completed (laptop = 9; cart = 3), the data yielded information that can be suggestive of trends in teachers thoughts regarding the benefits of students using laptops as a learning tool. As with the student survey responses, both the laptop and cart teachers were generally positive about the laptops and unanimously agreed that use of laptops had increased students' interest in learning. However, the laptop teachers had greater agreement than cart teachers that the laptops helped to increase student writing and research skills, their overall performance and grades, and the ability to work with other students. The laptop teachers also reported higher agreement than cart teachers that the use of laptops had increased their personal ability to use computers, to integrate student use of computers into lessons, and to use higher-level and project-based learning in the classroom. There were no notable difficulties reported regarding student use of laptops in the classroom.

Even though the data represent only a few teachers, the results suggest that laptop teachers experience greater benefits from student use of laptops than teachers who use the mobile carts. Perhaps this difference might be attributed to the laptop teachers knowing that students always have computers, so the teachers do not have to create special a "computer lesson plan" because integration is a natural part of everyday teaching and learning. Another contributing factor might be the extra accountability placed on the laptop teachers because parents are paying for the computers and "expect" the laptop teachers to regularly include them in student activities.

CONCLUSIONS

The Year 3 evaluation results are supportive of the beneficial impacts of the laptop program on students and teachers, although the differences were less striking than those found in the Year 1 and 2 studies. The reasons seem largely due to (a) both laptop and cart teachers had been trained to integrate technology via the NTeQ model, and (b) both groups had access to one Internet-connected laptop per student during integration lessons. Although both laptop and cart teachers implemented non-traditional methodologies, such as acting as coach/facilitators, engaging students in sustained writing and the use of computers as a learning tool, there was infrequent use of other student-centered strategies found in the NTeQ Model, such as cooperative learning, higher-level feedback and questioning, project-based learning, or integration of subject areas. As mentioned earlier, it may be useful to target professional development toward these strategies to better ensure student engagement in meaningful activities that result in increased student achievement.

The laptop students once again outperformed the control students in writing and problem-solving abilities. Although this year's study did not find significant differences in sustained writing activities for laptop vs. cart students, the laptop students did indicate that they use the computers more extensively for language arts lessons and that the laptop had increased their interest in learning and getting better grades. These differences combined with the fact that the laptop students clearly had more time to use the computers for classroom and homework activities are suggestive that a causal connection to higher writing ability is very likely. Similarly, laptop students' continuous access to computers and more frequent engagement in independent inquiry and research, use of the Internet and cooperative learning could easily be construed as contributing to their enhanced ability to process information and solve problems. With regard to only one difference emerging between laptop and cart student achievement results in mathematics, science, and social studies, the data from this evaluation are too limited to offer a supportive argument for the results. However, the higher achievement on mathematics benchmark 2 could conceivably be associated to laptop students more frequent use of computers in mathematics, along with the previously listed benefits.

In conclusion, even though the classroom environments and practices in laptop and cart classrooms are very similar, the laptop students emerge with more confidence in the educational benefits of using computers and with better writing and problem-solving skills. Thus the continuous access and added responsibility of having personal computers results in students being better prepared to meet the challenges offered in today’s highly technical society. However, the feasibility of providing every student with a laptop is financially unrealistic. Therefore, if laptop carts were made more readily available to K-12 teachers trained in the NTeQ approach, perhaps cart students could achieve benefits similar to the laptop students. Although, these results are promising, it is clear that further research that investigates student access to and educational use of laptops is needed.

ANYTIME, ANYWHERE LEARNING
FINAL EVALUATION REPORT OF THE LAPTOP PROGRAM: YEAR 3

This report summarizes the results of an evaluation study of the Year 3 implementation of the Anytime, Anywhere Learning (laptop program) implemented in Walled Lake Consolidated Schools (WLCS). The overall purpose of the Year 1 (Ross, Lowther, Plants, & Morrison, 2000) and Year 2 evaluations (Ross, Lowther, & Morrison, 2001) was to determine the educational impact of providing 5^{th}, 6^{th}, and 7^{th} grade students with access to laptop computers with regard to classroom learning activities, technology usage, writing achievement and problem-solving ability. The purpose of the Year 3 study was to determine the effectiveness of providing 5th grade students with access to laptop computers and if differences occur based on the amount of time (24 hours per day vs. class-time only) and/or type of access (personal laptop vs. laptop on school mobile cart) to the computers.

In the Year 1 evaluation, the findings showed that Laptop students were using computers more extensively and skillfully in their classrooms than were non-Laptop students. Importantly, usage of the computers was significantly more meaningfully integrated with curriculum in Laptop than in non-laptop classrooms. Laptop students also significantly surpassed non-Laptop students in writing skills, an outcome considered attributable to the increased opportunities to practice writing via the computer. In contrast to the Year 1 evaluation, the Year 2 study revealed relatively few differences in teaching methods between laptop and Computer-Extended (CE) classrooms (with 1 to 5+ computers available for student use), perhaps due to the CE classes also having NTeQ-trained teachers and enhanced technology resources. However, consistent across Year 1 and Year 2 studies was the laptop students' more frequent usage of the computer as a learning tool – specifically, greater use of word-processing and CD referencing software. Also consistent with Year 1 results were the differences in student achievement as seen in laptop students demonstrating superior writing and problem-solving skills as compared to the CE students.

WLCS laptop program. The WLCS laptop program is based on the Anytime, Anywhere Learning (AAL) program (AAL, 2000), which has been in schools since 1996 and has impacted more than 100,000 students and teachers. The goal of the AAL program is to provide students the knowledge, skills and tools to learn anytime and anywhere. The WLCS laptop program is a voluntary project that requires parents to purchase a laptop for the students that meets minimum district requirements. The laptop classrooms were equipped with wireless access to the Internet and printers. The program provided Year 1 students and parents the opportunity to receive training on basic computer skills. Year 2 and 3 students and parents received a software tutorial for learning basic computer skills.

Year 1 of the laptop program began with 26 teachers who taught grades 5 and 6. These teachers received ten full days of professional development prior to the 1999-2000 academic year and six one-half day sessions during the year. For Year 2, the 5^{th} and 6^{th} grade students took their laptops with them to the 6^{th} and 7^{th} grades and 8 new 5^{th} grade laptop classrooms were added. Year 3 involved all students taking their laptops to the next grade level and adding new 5^{th} grade classes. Teachers new to the program received one-on-one training from a previously trained laptop teacher who was hired as a full-time facilitator of the laptop program. As in Year 1 and 2, the Year 3 training was based on the iNtegrating Technology for inQuiry (NteQ) model (Morrison & Lowther, 2002), which provides teachers a framework to develop problem-based lessons that utilize real-world resources, student collaboration, and the use of computer tools to reach solutions. The lessons are typically structured around projects which engage the students in critically examining community and global issues, while strengthening student research and writing skills.

RESEARCH QUESTIONS

The Year 3 evaluation of the laptop program was structured around six primary research questions that focused on classroom practices, student achievement, and student behaviors and attitudes. Also of interest was the reaction and support of teachers involved with the laptop program or those who used mobile laptop carts (cart). The research questions are listed below:

- What differences emerge in teaching strategies used during a computer-supported lesson in laptop versus cart classrooms?
- Do laptop students differ from cart students in their writing skills?
- Do laptop students differ from Cart students in their approach to problem solving?
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- How do students perceive the use and access of laptop computers?
- What do teachers perceive as the benefits and problems of integrating technology in laptop vs. cart classrooms?

EVALUATION DESIGN AND MEASURES

The evaluation period extended from September 2002 through May 2003. The evaluation design was based on both quantitative and qualitative data collected from 5th grade students and teachers involved either with the laptop program or in classrooms using mobile laptop carts from which each student was provided a laptop computer. Participants came from four schools within WLCS. Comparative analyses were completed for teaching activities and learning outcomes and descriptive analyses were completed for student and teacher reactions to the laptop program or using mobile laptop carts.

PARTICIPANTS

The participant pool from which Year 3 data were randomly selected included all 5th grade teachers and students involved with the laptop program and randomly selected 5th grade teachers and students who routinely used the mobile laptop carts. During the 2002-2003 school year, there was greater access to the laptop carts at the fifth grade level than at other grade levels. Therefore, by focusing on the fifth grade classes, it was more likely that a student that was not in the laptop group would also have classroom access to a laptop computer.

The student to computer ratio in both the laptop classroom and the classrooms using the mobile laptop cart was typically one laptop computer per student. The numbers of participants by evaluation measure can be seen in Table 1.

Table 1

Evaluation Measure by Number of Laptop and Cart Participants

Evaluation Measure	Total Number	Number by Participant Group
School Observation Measure	19	10 laptop classes 09 cart classes
Survey of Computer Use	19	10 laptop classes 09 cart classes
Writing Test	272	132 laptop students 140 cart students
District Mathematics Benchmark (1-4), Science and Social Studies Test Scores	466	243 laptop students 223 cart students
Problem-Solving Test	272	138 laptop students 134 cart students
Student Survey	366	171 laptop students 195 cart students
Teacher Survey	12	09 laptop teachers 03 cart teachers

MEASURES

The data set for the evaluation included classroom observations, student writing test scores, district benchmark mathematics (1-4), science, and social studies test scores, problem-solving results, and student and teacher survey responses. Descriptions of each measure and its administration procedure are given below.

CLASSROOM OBSERVATIONS

Trained observers conducted targeted classroom visits to collect frequency data regarding observed instructional practices. The visits were considered targeted because observations were scheduled in advance with randomly-selected laptop teachers and teachers who regularly use the mobile laptop cart. The teachers were instructed to deliver a lesson that integrates student use of laptop computers. The data collection instruments were the School Observation Measure (SOM), the Survey of Computer Use (SCU), and the Rubric for Student-Centered Activities (RSCA).   The SOM was used to collect data regarding overall classroom activities, the SCU for student use of computers, and the RSCA to capture more detailed information about student-centered activities during the targeted observations. The classroom observation instruments are described below.

SOM. The SOM was developed to determine the extent to which different common and alternative teaching practices are used throughout an entire school (Ross, Smith, & Alberg, 1999). The standard, or *whole-school SOM* procedure involves observers' visiting 10-12 randomly selected classrooms, for 15 minutes each, during a three-hour visitation period. The observer examines classroom events and activities descriptively, not judgmentally. Notes are taken relative to the use or nonuse of 24 target strategies. At the conclusion of the three-hour visit, the observer summarizes the frequency with which each of the strategies was observed across all classes in general on a data summary form. The frequency is recorded via a 5-point rubric that ranges from (0) Not Observed to (4) Extensively. Two global items use a 3-point scale (Low, Moderate, and High) to rate, respectively, the level of academically-focused instructional time and student attention and interest.

To ensure the reliability of data, observers received a manual with definitions of terms, examples and explanations of the target strategies, and a description of procedures for completing the instrument. The target strategies include traditional practices (e.g., direct instruction and independent seatwork) and alternative, predominately student-centered methods associated with educational reforms (e.g., cooperative learning, project-based learning, inquiry, discussion, using technology as a learning tool). The strategies were identified through surveys and discussions involving policy makers, researchers, administrators, and teachers, as those most useful in providing indicators of schools' instructional philosophies and implementations of commonly used reform designs (Ross, Smith, Alberg, & Lowther, in press).

After receiving the manual and instruction in a group session, each observer participates in sufficient practice exercises to ensure that his/her data are comparable with those of experienced observers. In a reliability study (Lewis, Ross, & Alberg, 1999), pairs of trained observers selected the identical overall response on the five-category rubric on 67% of the items and were within one category on 95% of the items. Sterbinsky (2003) reported appropriate levels of reliability using at least the average of five SOMs to measure classroom practices.

For the Year 3 laptop program evaluation, the focus was the program within the school (laptop vs. cart) rather than the whole school. Accordingly, laptop and cart teachers were the basic observation samples. Because individual teachers are likely to be more consistent in their teaching orientations than are multiple teachers in a school, one *SOM* was based on 60 continuous minutes of observation, divided into about 4 (rather than 10-12) 15-minute segments. These 4 observation periods were then summarized on one *SOM* Data Summary form. Specifically, a total of 19 *SOM* observation periods were conducted in 6 schools during the spring 2003 academic year. Of the 19 observation periods, approximately 53% (10) were conducted in laptop classrooms and approximately 47% (9) in cart classrooms.

SCU. A companion instrument to SOM is the Survey of Computer Use (SCU) (Lowther & Ross, 2001). The SCU was completed as part of the SOM observation sessions, where SCU data was also recorded in 15-minute intervals and then summarized on an overall data form.

The SCU was designed to capture exclusively *student* access to, ability with, and use of computers rather than teacher use of technology. Therefore, four primary types of data are recorded: (a) computer capacity and currency, (b) configuration, (c) student computer ability and (b) student activities while using computers. Computer capacity and currency is defined as the age and type of computers available for student use and whether or not Internet access is available. Configuration refers to the number of students working at each computer (e.g., alone, in pairs, in small groups). Student computer ability is assessed by recording the number of students who are computer literate (e.g., easily used software features/menus, saved or printed documents) and the number of students who easily use the keyboard to enter text or numerical information.

The next section of the *SCU* focuses on student use of computers with regard to: the types of activities, subject areas of activities, and software being used. The computer activities are divided into four categories based on the type of software tool: production tools, Internet/research tools, educational software and testing software. Within each category, primary types of software are identified. For example, under Production Tools, the software includes: word processing, databases, spreadsheets, draw/paint/graphics, presentation (e.g., PowerPoint ™), authoring (e.g., KidPix ™), concept mapping (e.g., Inspiration), and planning (MS Project ™). For the Internet/research tools, three types of software are included: Internet browser, CD reference materials, and communications (e.g., email, listservs, chat rooms). The Educational Software also has three types of software: drill/practice/tutorial, problem-solving (e.g., Riverdeep ™) and process tools (e.g., Author's Toolkit ™). The last type, Testing Software includes individualized/tracked (e.g., Accelerated Reader), Generic, and Other. With this type of recording system, several activities can be noted during the observation of one student working on a computer. For example, if a student gathered data from the Internet, created a graph from the data, then imported the graph into a PowerPoint presentation, the observer would record three types of software tools as being observed: Internet browser, spreadsheet, and presentation. This section ends by identifying the subject area of each computer activity. The categories include: language arts, mathematics, science, social studies, other, and none. The computer activities and software being used are summarized and recorded using a five-point rubric that ranges from (0) Not Observed to (4) Extensively observed.

The final section of the SCU is an "Overall Rubric" designed to assess the degree to which the activity reflects "meaningful use" of computers *as a tool* to enhance learning. The rubric has four levels: 1 – Low-level use of computers, 2 – Somewhat meaningful, 3 – Meaningful, and 4 - Very meaningful.

As with the SOM, 19 SCU observations were completed; 10 in laptop classrooms and 9 in classrooms using mobile laptop carts (cart).

RSCA. The Rubric for Student-Centered Activities (RSCA) was developed by CREP (Lowther, Ross, & Plants, 2000) as an extension to SOM and SCU. The RSCA was used by observers to more closely evaluate the degree of learner engagement in seven selected areas considered fundamental to the goals of increasing student-centered learning activities (cooperative learning, project-based learning, higher-level questioning, experiential/hands-on learning, student independent inquiry/research, student discussion, and students as producers of knowledge using technology). These strategies reflect emphasis on higher-order learning and attainment of deep understanding of content and whether or not technology was utilized as a component of the strategy. Such learning outcomes seem consistent with those likely to be engendered by well-designed, real-world linked exercises, projects, or problems utilizing technology as a learning tool. Each item includes a two-part rating scale. The first is a four-point scale, with 1 indicating a very low level of application, and 4 representing a high level of application. The second is a Yes/No option to the question: "Was technology used?" with space provided to write a brief description of the technology use. The RSCA was completed as part of the 19 SOM/SCU observation periods.

STUDENT ACHIEVEMENT

As a means of determining the impact of the laptop program on student performance, the results from the following district assessments were used to compare laptop vs. cart students: mathematics benchmarks (1-4), science, social studies, and the writing test.

Mathematics, Science and Social Studies Tests. The Michigan Department of Education content standards for curriculum provide descriptions of what students should know and be able to do in the subject areas of English language arts, social studies, mathematics and science. In addition, each standard has associated benchmarks to further clarify the content standards. The standards and benchmarks are not a state curriculum, but are specifically designed to be used by local districts as they develop their curricula and as a basis for revisions and new test development for the MEAP and High School Proficiency Tests.

Writing Test. The WLCS's *Writing Scoring Guide* was used to assess prompted writing samples from laptop and cart students. The District's assessment examines four dimensions of writing: Ideas and Content, Organization, Style, and Conventions. The *Scoring Guide* rubric was used to categorize the writing samples into one of four levels on each dimension: Mature (4), Capable (3), Developing (2), Emerging (1). A copy of the rubric criteria for each dimension x level category is provided in Appendix B.

All WLCS students in grades 3 through 8 complete the writing test at the end of the academic year. The assessment involves students being asked to write a letter of introduction to their "new" teacher for next year. For this study, 272 5th grade (132 laptop and 140 cart) writing samples were randomly selected from those taken for the district test for comparative analysis. Experienced reviewers from the district used the district's four-point rubric to conduct a blind assessment of the writing samples for each of the four dimensions, yielding four scores per student.

PROBLEM-SOLVING TASK

To assess the ability of students to comprehend problems and formulate solutions, a problem-solving task was devised for this study. The task posed the following problem situation:

> **POP CANS AT THE PARK**
>
> There are several soda pop machines at the city parks. When you buy a can of soda pop, it costs 10 cents extra. This 10 cents is for a deposit that you get when you take the can back for recycling. The park managers have found a large number of cans in the parks' trashcans. The City Parks Commission wants to have more people recycle their cans. They have asked you to help them study this problem *all summer*.
>
> **Is there a way to help people recycle their soda cans?**
>
> Please tell us *how* you will solve this problem. Describe with details what you would do. Describe the materials and resources you will use. Would you work with others? If so, describe how you would work with them.
>
> Tell us how you will determine:
>
> - Which park has the largest number of cans in the trash?
> - How much money does the vending company keep from cans that are never turned in for a deposit?
> - What are the benefits of recycling - does it really make a difference in saving natural resources?
> - What might you do to encourage people to recycle the cans rather than putting them in the trash? (List as many ideas as you can.)
> - How could you determine if increasing the deposit amount would increase the return of cans to collect the deposit?
> - How would you present the results to the Parks Commission?

Laptop and cart teachers received written instructions for administering the problem-solving task. These instructions indicated that students had 45 minutes to complete the task and should take the test via computer. Teachers were asked to read a statement to students that instructed them to not include their name or any other identifying marks on their work and that participation was voluntary. The problem-solving task and administration procedures can be found in Appendix C.

Random samples of 138 laptop and 134 cart students in the 5th grade were administered the task. Trained reviewers judged the students' responses on a rubric composed of 7 Components x 3 Performance Levels (see Appendix D). Components consisted of: "Understands problem," "Identifies what is known about problem," "Identifies what needs to be known to solve the problem," "Determines how the data need to be manipulated to solve the problem," "Describes use of technology," "Describes how to present findings, and Collaborative learning."

STUDENT REACTIONS

To increase understanding of the implementation processes and outcomes of the laptop program, a survey was administered to randomly selected students participating in the laptop program and cart classrooms. Details of the survey are below.

Student Survey. The Student Survey included 17 multiple choice, Likert-type items. The survey begins by asking students how the laptop has impacted them personally. These items addressed the student's computer skills, interest and improvement in school, and if the laptop increased the student's desire to get better grades. The next section explored if students worked with other students while using the laptop and asked students to identify the subject areas covered in laptop lessons. The final section asked five questions regarding barriers to using the laptop. These items addressed access to electrical outlets, having enough desk space to use the laptops, setting and working with the laptop, and comfort level in using the laptop. The laptop student survey was administered online during class time to 366 5th grade students (171 laptop; 195 cart).

TEACHER REACTIONS

The 5th grade laptop and cart teachers at the six participating schools were asked to complete a teacher survey which is described below. A total of 12 teachers completed the survey (9 laptop, 3 cart).

Teacher Survey. The teacher survey was comprised of 25 items. All items used a Likert-type response method. The items were divided into four categories: Personal Impact, Student Impact, Student Use and Barriers to use. The Personal Impact items asked if the laptop program had increased their computer skills, their ability to design integration and project-based lessons, and/or communications with students and parents. The Student Impact items asked teachers their impressions about the laptop program's impact on students' interest in learning, grades, writing skills, research skills, or ability to work with others. The section on Student Use focused on student grouping during computer use and subject areas and the types of software used in laptop lessons. The final section, Barriers to Use, addressed scheduling the laptops, battery life, technical problems, working space, and student computer skills.

RESULTS

SCHOOL OBSERVATION MEASURE (SOM©)

As indicated in the description of *SOM*, the observation procedure focused on 24 instructional strategies using a five-point rubric (0 = Not Observed, 1 = Rarely, 2 = Occasionally, 3 = Frequently, and 4 = Extensively). Two global items use a 3-point scale (Low, Moderate, and High) to rate, respectively, the level of academically-focused instructional time and student attention and interest. Each observation lasted approximately one hour. At the end of each session, the observer completed the final rubrics and ratings. The total number of observations completed was 10 for the laptop classrooms and 9 for the cart classrooms.

Observed vs. Not Observed. In an initial analysis, we collapsed the rubric categories 2-4 into one category to yield a two-category scheme reflecting the percentage of visits in which a strategy was either observed or not observed. A summary of the overall findings for laptop and cart classes, listed by percentage of times observed, is presented in Table 2.

For laptop classes (n = 10), strategies observed at least once in 50% or more of the visits were: technology as a learning tool (80%), teacher as a coach/facilitator (80%), independent seatwork (50%), higher level instructional feedback (50%), and independent inquiry/research (50%). For cart classes (n = 9), strategies observed at least once in 50% or more of the visits were: technology as a learning tool (100%), teacher as a coach/facilitator (78%), independent seatwork (68%), and sustained writing/composition (56%). There was clearly an overlap of three strategies, but also differences between the two groups of classes. Specifically, strategies showing a difference of 20% or more in the percentage of visits observed were: independent inquiry/research (laptop = + 39%), high level instructional feedback (laptop = +28%) technology as a learning tool (cart = +20%), and sustained reading (cart = +22).

To determine whether there were any significant differences between the laptop classes and the cart classes, the mean rubric scores (range = 0-4) were compared using a t-test on each of the strategies. None of the items was found to be significantly different between the two groups.

Table 2

School Observation Measure (SOM) Data Summary

Strategies	Laptop (n=10) Observed	Laptop (n=10) Not Observed	Cart (n=9) Observed	Cart (n=9) Not Observed
Direct instruction	10.0	90.0	22.2	77.8
Team teaching	0.0	100.0	0.0	100.0
Cooperative/collaborative learning	10.0	90.0	11.1	88.9
Individual tutoring	10.0	90.0	0.0	100.0
Ability groups	0.0	100.0	0.0	100.0
Multi-age grouping	0.0	100.0	0.0	100.0
Work centers	0.0	100.0	0.0	100.0
Higher level instructional feedback	50.0	50.0	22.2	77.8
Integration of subject areas	0.0	100.0	0.0	100.0
Project-based learning	10.0	90.0	0.0	100.0
Use of higher-level questioning	20.0	80.0	22.2	77.8
Teacher as a coach/facilitator	80.0	20.0	77.8	22.2
Parent/community involvement	0.0	100.0	0.0	100.0
Independent seatwork	50.0	50.0	66.7	33.3
Experiential, hands on learning	0.0	100.0	0.0	100.0
Systematic individual instruction	0.0	100.0	0.0	100.0
Sustained writing/composition	40.0	60.0	55.6	44.4
Sustained reading	0.0	100.0	22.2	77.8
Independent inquiry/research	50.0	50.0	11.1	88.9
Student discussion	0.0	100.0	0.0	100.0
Computer for instructional delivery	20.0	80.0	0.0	100.0
Technology as a learning tool	80.0	20.0	100.0	0.0
Performance assessment	10.0	90.0	0.0	100.0
Student self-assessment	0.0	100.0	0.0	100.0

Full rubric. Table 3 extends the results to all five rubric categories and the two summary items for the laptop and cart classrooms. For laptop, strategies viewed occasionally or more (frequently or extensively) in at least 30% of the classrooms include technology as learning tool (80%), teacher acting as coach or facilitator (70%), independent seatwork (50%), independent inquiry/research on the part of the student (50%), and sustained writing (40%). For cart classrooms, the strategies viewed occasionally or more in at least 30% of the visits included technology as a learning tool (100%), teacher acting as coach or facilitator (78%), independent seatwork (67%), and sustained writing (56%). At the other extreme are strategies never or rarely observed during the visits. Those in laptop classes reaching 95% or higher for these two lowest categories combined were team teaching, ability grouping, multi-age groups, work centers, integration of subject areas, parent/community involvement, experiential hands-on learning, and systematic individual instruction, sustained reading, and student discussion. Those never or rarely observed in cart classes were team teaching, individual tutoring, ability grouping, multi-age groups, work centers, integration of subject areas, project-based learning, parent/community involvement, experiential hands-on learning, systematic individual instruction, student discussion, and computer for instructional delivery. On the two final summary items, it should be noted that in laptop classes, academically-focused class time was rated as high in 100% of the visits, while the level of student interest/engagement was rated as high in 60%. In cart classes, by comparison, these ratings were 67% and 56%, respectively.

To determine whether significant differences between laptop and cart SOM results, t-tests for independent samples were performed on each item. The analysis revealed no significant differences between the two groups.

Table 3

School Observation Measure (SOM) Data Summary

Laptop N = 10
Cart N = 9

The extent to which each of the following was used or present in the classroom.	Year	Percent None	Percent Rarely	Percent Occasionally	Percent Frequently	Percent Extensively
Instructional Orientation						
Direct instruction (lecture)	Laptop	90.0	10.0	0.0	0.0	0.0
	Cart	77.8	22.2	0.0	0.0	0.0
Team teaching	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Cooperative/collaborative learning	Laptop	90.0	0.0	10.0	0.0	0.0
	Cart	88.9	0.0	11.1	0.0	0.0
Individual tutoring (teacher, peer, aide, adult volunteer)	Laptop	90.0	0.0	0.0	0.0	10.0
	Cart	100.0	0.0	0.0	0.0	0.0
Classroom Organization						
Ability groups	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Multi-age grouping	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Work centers (for individuals or groups)	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Instructional Strategies						
Higher level instructional feedback (written or verbal) to enhance student learning	Laptop	50.0	30.0	10.0	0.0	10.0
	Cart	77.8	11.1	11.1	0.0	0.0
Integration of subject areas (interdisciplinary/thematic units)	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Project-based learning	Laptop	90.0	0.0	0.0	0.0	10.0
	Cart	100.0	0.0	0.0	0.0	0.0
Use of higher-level questioning strategies	Laptop	80.0	10.0	0.0	10.0	0.0
	Cart	77.8	11.1	11.1	0.0	0.0
Teacher acting as a coach/facilitator	Laptop	20.0	10.0	10.0	10.0	50.0
	Cart	22.2	0.0	33.3	0.0	44.4
Parent/community involvement in learning activities	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0

Table 3 (continued)

The extent to which each of the following was used or present in the classroom.	Year	Percent None	Percent Rarely	Percent Occasionally	Percent Frequently	Percent Extensively
Student Activities						
Independent seatwork (self-paced worksheets, individual assignments)	Laptop	50.0	0.0	0.0	0.0	50.0
	Cart	33.3	0.0	11.1	33.3	22.2
Experiential, hands-on learning	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Systematic individual instruction (differential assignments geared to individual needs)	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Sustained writing/composition (self-selected or teacher-generated topics)	Laptop	60.0	0.0	0.0	0.0	40.0
	Cart	44.4	0.0	11.1	11.1	33.3
Sustained reading	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	77.8	11.1	0.0	0.0	11.1
Independent inquiry/research on the part of students	Laptop	50.0	0.0	10.0	20.0	20.0
	Cart	88.9	0.0	0.0	0.0	11.1
Student discussion	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Technology Use						
Computer for instructional delivery (e.g. CAI, drill & practice)	Laptop	80.0	0.0	10.0	0.0	10.0
	Cart	100.0	0.0	0.0	0.0	0.0
Technology as a learning tool or resource (e.g. Internet research, spreadsheet or database creation, multi-media, CD ROM, Laser disk)	Laptop	20.0	0.0	20.0	0.0	60.0
	Cart	0.0	0.0	0.0	33.3	66.7
Assessment						
Performance assessment strategies	Laptop	90.0	0.0	0.0	0.0	10.0
	Cart	100.0	0.0	0.0	0.0	0.0
Student self-assessment (portfolios, individual record books)	Laptop	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Summary Items				Low	Moderate	High
Academically focused class time	Laptop			0.0	0.0	100.0
	Cart			11.1	22.2	66.7
Level of student attention/ interest/engagement	Laptop			0.0	40.0	60.0
	Cart			0.0	44.4	55.6

Summary of SOM findings. In summary, the SOM data revealed relatively few differences in teaching methods between laptop and cart classes. This is not surprising considering that both the laptop and cart teachers were trained in the NTeQ model and had substantial access to computers for instructional purposes. Thus, both groups of teachers were similar in the degree to which they acted as coach/facilitators, engaged students in sustained writing and the use of computers as a learning tool or resource. Though not significant, the laptop students were engaged in more independent inquiry research as compared to the cart students and were more frequently in classes with a high level of academically focused class time.

RUBRIC FOR STUDENT-CENTERED ACTIVITIES (RSCA)

Results address the percentage of sessions in which each RSCA strategy was observed at least once, the quality/depth of observed strategy applications, and the percentage of sessions in which technology was used with the observed strategy. Because the RSCA was used in targeted observations of lessons that were to include the use of technology to support learning, computer use was expected to be viewed at sometime during the lesson. The rubric rating (1 to 4) for each of the strategies was calculated when the given strategy was observed. If the strategy was not seen, the associated rating of “0” was excluded from the analysis because it would negatively bias the overall computation of quality or effectiveness.

Table 4 summarizes descriptive results from the RSCA. For the laptop classes, project-based learning (M = 4.00) was considered the most meaningful. The strategy with the lowest mean score (M = 1.67) was students as producers of knowledge. For the cart classes, independent inquiry/research was the most meaningful (M = 2.20) and the lowest mean score was higher-level questioning strategies (M = 1.00). Notably, three of the seven strategies, (experiential, hands-on learning and student discussion for both classes, and project-based learning for the cart classes) were not observed.

Comparisons were made between the laptop classes and the cart classes on the seven rubric items using the independent t-tests. The results indicated that there were no statistical significances between the two groups of classes.

Table 4

Rubric for Student-Centered Activities (RSCA) Item Ratings by Percentage Observed and Mean Scores

Laptop N = 10
Cart N = 9

RSCA Items	Year	% Observed	Rubric Rating* - Percentage Observed				*M**
			1	2	3	4	
Cooperative Learning	Laptop	10.0	0.0	10.0	0.0	0.0	2.00
	Cart	11.1	0.0	11.1	0.0	0.0	2.00
Project-Based Learning	Laptop	10.0	0.0	0.0	0.0	10.0	4.00
	Cart	0.0	0.0	0.0	0.0	0.0	.
Higher-Level Questioning Strategies	Laptop	20.0	20.0	0.0	0.0	10.0	1.00
	Cart	22.2	22.2	0.0	0.0	0.0	1.00
Experiential, Hands-On Learning	Laptop	0.0	0.0	0.0	0.0	0.0	.
	Cart	0.0	0.0	0.0	0.0	0.0	.
Independent Inquiry / Research	Laptop	50.0	20.0	10.0	10.0	10.0	2.20
	Cart	11.1	0.0	11.1	0.0	0.0	2.00
Student Discussion	Laptop	0.0	0.0	0.0	0.0	0.0	.
	Cart	0.0	0.0	0.0	0.0	0.0	.
Students as Producers of Knowledge	Laptop	90.0	70.0	0.0	0.0	20.0	1.67
	Cart	66.6	44.4	22.2	0.0	0.0	1.33

** a rating of 1 = low level of application; 4 = high level of application.*

Technology use. After each RSCA item, the respondent was asked to indicate whether or not technology was used in conjunction with the particular strategy. Table 5 summarizes the results for the laptop classes and the cart classes. For the laptop classes, the highest frequency of technology use during student-centered activities was independent inquiry/research (50%). In contrast, independent inquiry/research (11%) was the only student-centered activity for which technology was used in the cart classrooms.

Table 5

Percent of RSCA Strategies that Used Technology

RSCA Items	% with Technology Use	
	Laptop (n=10)	Cart (n=9)
Cooperative Learning	10.0%	0.0%
Project-based Learning	10.0%	0.0%
Higher-Level Questioning Strategies	0.0%	0.0%
Experiential Hands-on Learning	0.0%	0.0%
Independent inquiry/research	50.0%	11.1%
Student Discussion	0.0%	0.0%

SURVEY OF COMPUTER USE (SCU©)

As with the SOM, data from the SCU were collected during prescheduled lessons in which teachers were asked to have students use laptop computers. A summary of the observation results is provided in Table 6.

Computer configuration. As noted in Table 6, all (100%) the laptop classes and cart classes had 11 or more computers or digital tools. In addition, all (100%) of the computers for both groups were up-to-date and connected to the Internet.

Computer use. Not surprisingly, the observations revealed that nearly all (91-100%) students used computers or digital tools in all (100%) of the laptop classes and 89% of the cart classes. With regard to student grouping patterns, the observations for both the laptop classes and the cart classes showed that all students (100%) worked alone. There was, however, a striking difference in the observed computer literacy and keyboarding skills of students in the laptop vs. cart classes. For 80% of the observations, the computer literacy skills of students in laptop classes were rated as "very good" as compared to only 22% for the cart students. In terms of keyboarding skills, laptop students were rated as "very good" during 70% of the observations while cart students were rated "very good" for 33%.

Production tools used by students. As shown in Table 6, only three types of production tools were seen occasionally or more during visits to the laptop and/or cart classes. The most commonly used software for both groups was word processing, which was extensively used during approximately 60% of the visits (laptop = 60%; cart = 56%). However, students in the cart classes extensively used presentation software during 44% of the visits as compared to only 20% in the laptop classes. The third production tool was draw/paint/graphic software, which was only seen occasionally during 30% of the visits to laptop classes. Software tools, which are associated with students manipulating data and the use of critical thinking skills, such as spreadsheets and databases, were not observed.

Internet/research tools used by students. Usage of an Internet browser was observed occasionally or more in 60% of the laptop classes as compared to only 33% of the cart classes. Student usage of CD reference tools or communication tools was not observed in either the laptop or cart classes.

Educational software use by students. Student usage of educational software was only observed during 10% of the visits to the laptop classrooms. During this time, the students extensively used drill/practice/tutorial. Educational software usage was not observed in the cart classes.

Testing software. The observation results did not reveal student use of testing software in the laptop or cart classes.

Computers/digital tools used by students. The majority of the observations (90%) indicated that laptop computers were extensively used in the laptop classes, as expected. However, desktop computers were extensively used and digital accessories rarely used during 10% of the laptop visits. The observations revealed a similar pattern for the cart classes, with 78% extensive usage of laptop computers and 13% extensive usage in desktop computers.

Subject Area of Computer Activities. Language arts was the most frequently observed subject area focus of the computer activities. Specifically, production tools were used more frequently in language arts (laptop = 80%; cart = 67%) than in other subjects. Internet/ research tools were also used more frequently in language art classes, however with less frequency than the production tools (laptop = 30%; cart = 11%).

Meaningfulness of computer use. Somewhat meaningful use of computers was occasionally or extensively seen in the majority of the laptop (80%) and cart (56%) observations. However, meaningful or very meaningful use of computers was occasionally to extensively observed in 50% of the laptop classes as compared to only 11% of the cart classes.

Summary of SCU findings. Data from the SCU revealed that students in both the laptop and cart classes primarily worked alone on up-to-date, Internet-connected computers. The majority of the laptop students were considered to have very good computer literacy and keyboarding skills as compared to only one third or less of the cart students. Word processing was the most frequently used software by both groups; however laptop students more frequently used the Internet than the cart students. Across both groups, language arts was most frequently the subject area of the computer activities, yet, computers were used to a lesser degree for social studies, science, and mathematics. Regarding the meaningfulness of the computer activities, most were considered to be somewhat meaningful, with the laptop students more frequently engaging in more meaningful activities than the cart students.

Table 6

Survey of Computer Use (SCU) Data Summary

Laptop N = 10
Cart N = 9

Computer Configuration	**Laptop**	**Cart**
Classrooms most frequently had the following number of computers or digital tools.		
None	0.0	0.0
One	0.0	0.0
2 - 4	0.0	0.0
5 – 10	0.0	0.0
11 or more	100.0	100.0
Up-to-date	100.0	100.0
Aging, but adequate	0.0	0.0
Outdated/limited capacity	0.0	0.0
No computers were observed	0.0	0.0
Classroom computers were most frequently		
Connected to the Internet	100.0	100.0
Not connected to the Internet	0.0	0.0
No computers were observed	0.0	0.0
Computer Use		
Classroom Computers or digital tools were most frequently used by:		
Few (less than 10%) students	0.0	0.0
Some (about 10-50%) students	0.0	0.0
Most (about 51-90%) students	0.0	11.1
Nearly all (91-100%) students	100.0	88.9
Students did not use computers	0.0	0.0
Students most frequently worked with computers or digital tools:		
Alone	100.0	100.0
In pairs	0.0	0.0
In small groups	0.0	0.0
Students did not use computers	0.0	0.0
Student computer literacy skills were most frequently:		
Poor	0.0	0.0
Moderate	20.0	77.8
Very good	80.0	22.2
Not observed	0.0	0.0
Student keyboarding skills were most frequently:		
Poor	0.0	0.0
Moderate	30.0	66.7
Very good	70.0	33.3
Not observed	0.0	0.0

Table 6 (continued)

Items	Year	Not Observed	Rarely	Occasionally	Frequently	Extensively
Production Tools Used by Students						
Word Processing	*Laptop*	20.0	0.0	20.0	0.0	60.0
	Cart	44.4	0.0	0.0	0.0	55.6
Database	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Spreadsheet	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Draw/Paint/Graphics	*Laptop*	60.0	10.0	30.0	0.0	0.0
	Cart	88.9	11.0	0.0	0.0	0.0
Presentation (e.g., MS PowerPoint)**	*Laptop*	40.0	40.0	0.0	0.0	20.0
	Cart	55.6	0.0	0.0	0.0	44.4
Authoring (e.g., HyperStudio)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Concept Mapping (e.g., Inspiration)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Planning (e.g., MS Project)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Other	*Laptop*	90.0	10.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Internet/Research Tools Used by Students						
Internet Browser (e.g., Netscape)**	*Laptop*	30.0	10.0	10.0	10.0	40.0
	Cart	44.4	22.2	11.1	0.0	22.2
CD Reference (encyclopedias, etc.)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Communications	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Other	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Educational Software Used by Students						
Drill/Practice/Tutorial	*Laptop*	90.0	0.0	0.0	0.0	10.0
	Cart	100.0	0.0	0.0	0.0	0.0
Problem Solving (Oregon Trail, SimCity, etc.)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Process Tools (Geometer's Sketchpad, etc.)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Other (See Addendum)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Testing Software						
Individualized/Tracked (e.g., Accelerated Reader)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Generic	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Other (see Addendum)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0

Table 6 (continued)

Items		Not Observed	Rarely	Occasionally	Frequently	Extensively
Computers/Digital Tools Used by Students						
Desktop Computers	*Laptop*	90.0	0.0	0.0	0.0	10.0
	Cart	87.5	0.0	0.0	0.0	12.5
Laptop Computers	*Laptop*	0.0	0.0	10.0	0.0	90.0
	Cart	11.1	0.0	0.0	11.1	77.8
Personal Data Assistants (PDA)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Graphing Calculator	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Information Processor (e.g., Alphaboard)	*Laptop*	100.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0
Digital Accessories (e.g., camera, scanner, probes)	*Laptop*	90.0	10.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0

Items		None	Other	Language	Mathematics	Science	S. Studies
Subject Areas of Computer Activities							
Production Tools	*Laptop*	10.0	0.0	80.0	20.0	20.0	30.0
	Cart	0.0	0.0	66.7	11.1	11.1	11.1
Internet/Research Tools	*Laptop*	40.0	0.0	30.0	10.0	20.0	20.0
	Cart	66.7	0.0	11.1	0.0	0.0	11.1
Educational Software	*Laptop*	90.0	0.0	0.0	10.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0	0.0
Testing Software	*Laptop*	100.0	0.0	0.0	0.0	0.0	0.0
	Cart	100.0	0.0	0.0	0.0	0.0	0.0

Survey of Computer Use (SCU) Data Summary: Overall Rubric

Overall meaningful use of computers		Not Observed	Rarely	Occasionally	Frequently	Extensively
Low level use of computers*	*Laptop*	70.0	10.0	0.0	10.0	10.0
	Cart	44.4	11.1	0.0	0.0	44.4
Somewhat meaningful use of computers*	*Laptop*	20.0	0.0	10.0	20.0	50.0
	Cart	33.3	11.1	11.1	11.1	33.3
Meaningful use of computers***	*Laptop*	70.0	0.0	20.0	10.0	0.0
	Cart	88.9	0.0	11.1	0.0	0.0
Very meaningful use of computers*	*Laptop*	80.0	0.0	0.0	0.0	20.0
	Cart	100.0	0.0	0.0	0.0	0.0

WRITING PERFORMANCE

Fifth-grade students in laptop and cart classes were asked to write, via word processing, a prompted essay (letter). A total of 272 students completed the essay with 132 being from laptop classrooms and 140 from cart classes. The essays were then scored in the blind (regarding students' enrollment in laptop vs. cart) on a rubric encompassing the four dimensions of Ideas and Content, Organization, Style, and Conventions. For each dimension, the essay was scored using a 4-point scale ranging from "emerging" (1) to "mature" (4) (see Appendix A for rubric descriptors). Mean performance scores for laptop and cart students were analyzed by group via a one-way multivariate analysis of variance (MANOVA) with the four dimension scores serving as the dependent variables (see Table 7). The MANOVA yielded a highly significant difference, $F(4, 267) = 9.16$, $p = .000$. Follow-up analyses showed significant advantages for the laptop over cart students on all four components, as seen in effect sizes ranging from +0.33 to +0.63. Effects of this magnitude represent educationally important impacts (see Cohen, 1988).

Table 7

A Summary of Items Showing Significant Differences Between Laptop and Cart

			Hypothesis		
Overall	*Hotellings T*	*F*	*df*	*Error df*	*p*
	0.14	9.16	4.00	267.00	0.000***

	Laptop		Cart				
Component/Rating	*M*	*SD*	*M*	*SD*	*F (1, 270)*	*p*	*ES*
1. Ideas and Content***	2.75	0.92	2.11	1.01	30.31	0.000	0.63
2. Organization**	2.54	0.94	2.17	1.02	9.44	0.002	0.37
3. Style**	2.28	0.91	1.96	0.96	8.40	0.004	0.34
4. Conventions**	3.03	0.79	2.75	0.86	7.83	0.006	0.33

**p<.05, **p<.01, ***p<.001*

Problem-Solving Performance

As described in the Method section, the problem-solving rubric consisted of seven components; each rated on a three-level scale (see Appendix C). Participants consisted of 272 5th graders, with 138 in the laptop group and 134 in the cart group. To determine if significant differences existed between the groups, a MANOVA was conducted to compare the two sets of data. Table 8 presents a summary of the results that depict a significant multivariate effect, $F(7, 264) = 4.60$, $p < .000$. Follow-up analyses of univariate effects revealed significant differences on five of the seven components: use of technology (laptop $M = 1.69$; cart $M = 1.31$), what is known (laptop $M = 1.47$; cart $M = 1.26$), presents findings (laptop $M = 1.56$; cart $M = 1.37$), understands problem (laptop $M = 1.68$; cart $M = 1.50$), and manipulates data (laptop $M = 1.89$; cart $M = 1.72$). Upon examination of the resulting Effect Sizes of the differences, the implied educational impact ranges from high for use of technology ($ES = +0.55$) to somewhat limited for manipulate data ($ES = +0.26$).

Table 8

A Summary of Items Showing Significant Differences Between Laptop and Cart on Problem Solving

Overall	*Hotellings T*	*F*	Hypothesis *df*	*Error df*	*p*
	0.12	4.60	7.00	264.00	0.000***

Component/Rating	Laptop (*n* =138) *M*	*SD*	Cart (*n* = 134) *M*	*SD*	*F (1, 270)*	*p*	*ES*
1. Understands Problem*	1.68	0.67	1.50	0.63	5.22	0.023	0.27
2. What is Known**	1.47	0.63	1.26	0.44	10.07	0.002	0.38
3. Needs to Know	1.42	0.60	1.31	0.48	2.99	0.085	0.20
4. Manipulate Data*	1.89	0.67	1.72	0.61	4.67	0.032	0.26
5. Use of Technology***	1.69	0.75	1.31	0.56	22.36	0.000	0.55
6. Present Findings*	1.56	0.71	1.37	0.62	5.60	0.019	0.28
7. Collaborative Learning	1.23	0.53	1.26	0.44	0.25	0.621	-0.04

**p<.05, **p<.01, ***p<.001*

Note: Differences between “Needs to Know” and “Collaborative Learning” were not significant.

ACHIEVEMENT ANALYSIS

Scores on the district administered mathematics (Benchmark1-4), science and social studies tests were used to gauge possible program effects on 466 (243 laptop, 223 cart) fifth grade students. The 4th grade (pre-laptop) MEAP mathematics total raw scores from 2001-2002 were analyzed to determine if significant differences existed between the laptop and cart students. The 4th grade scores were also used were used as a covariate to control for initial differences among students when making program comparisons. As seen in Table 9, results from an independent *t*-test revealed that the laptop students 4th grade mathematics MEAP scores were significantly higher than the scores for cart students ($t(431) = 4.51$, $p < 0.001$, $ES = .45$).

Table 9

Independent t-test for Pre-Laptop 4th Grade Mathematics MEAP Scores

	Laptop (n = 216)		**Cart (n = 217)**				
	M	SD	M	SD	*t (431)*	*p*	*ES*
4th Grade Mathematics MEAP Scores	351.88	72.31	321.54	67.65	4.51	0.000	0.45

Descriptive Analyses. Mean raw scores (*M*), and standard deviations (*SD*) were computed for mathematics (Benchmark 1-4), science, and social studies tests and the fourth grade (2001-2002) MEAP raw scores. The means for laptop students were directionally higher than the means of cart students on all tests (Table 10).

Table 10

Summary of Math Benchmark (1-4), Science and Social Studies Test Scores

		5th Grade Mathematics Benchmarks				5th Grade	
Program		**1**	**2**	**3**	**4**	**Science**	**Social Studies**
Laptop (*n*=243)	Raw *M*	86.51	89.32	84.01	84.21	564.17	532.17
	SD	12.78	12.44	17.58	26.97	26.62	39.81
	Adjusted *M**	84.21	86.96	81.27	82.79	564.47	533.03
Cart (*n* =223)	Raw *M*	80.09	77.83	78.46	80.95	558.42	523.38
	SD	13.60	16.75	17.44	17.15	22.15	35.26
	Adjusted *M**	82.39	80.19	81.20	82.36	558.13	522.53

The MANCOVA yielded a significant overall program effect: $F(6, 245) = 5.67$, $p<.001$. However, the univariate ANOVAs conducted on each test produced a significant effect on Mathematics Benchmark 2 (Geometry and Measurement – see Appendix A) only, with the laptop students scoring significantly higher $F(1,250) = 20.99$, $p<.001$ than the cart students (laptop $M^* = 86.96$; cart $M^* = 80.19$). The effect size for this difference was $ES = +.44$, indicating a moderate effect favoring the laptop group (Table 11).

Table 11

Means and Effect Sizes for All Subjects

Subject	**Group**	***M***	**Pooled within-Groups *SD***	***ES***
Mathematics Benchmark - 1	Laptop Cart	84.21 82.39	13.37	0.14
Mathematics Benchmark - 2	Laptop Cart	86.96 80.19	15.24	0.44
Mathematics Benchmark - 3	Laptop Cart	81.27 81.20	17.66	0.00
Mathematics Benchmark - 4	Laptop Cart	82.79 82.36	23.59	0.02
Science	Laptop Cart	564.47 558.13	25.06	0.25
Social Studies	Laptop Cart	533.03 522.53	38.23	0.27

STUDENT SURVEY

Section 1: Personal impact. Table 12 summarizes students' personal feelings about having a laptop for home and school or using a laptop at school only. The responses were positive overall for both groups. However, group differences arose in the degree of agreement. Laptop students were significantly more demonstrative about the improvements made in their interests and skills since using the laptops. The greatest difference was seen in increased computer skills ($\chi2=89.5$, $p=.001$). Cart students were significantly more likely to respond "No" or "Somewhat" to this question and significantly less likely to respond "A lot". laptop students also responded more positively to having more fun ($\chi2=18.14$, $p<.001$), being more interested in learning ($\chi2=32.45$, $p<.001$) and wishing to get better grades ($\chi2=25.60$, $p<.001$) due to using a laptop. Cart students responded "No" significantly more often when asked if using the laptop made them want to get better grades (42% vs. 18% for laptop students).

Table 12

Frequency of Agreement by group regarding Personal Impact

	No		Somewhat		A lot more		Total		
Agreement	N	%	N	%	N	%	N	χ^2	p-value
My computer skills are better because I use a laptop									
Cart	45	23%	96	49%	54	28%	195	89.5	.000
Laptop	5	3%	36	21%	130	76%	171		
Using a laptop has made school more fun.									
Cart	17	9%	57	29%	121	62%	195	18.14	.000
Laptop	3	2%	29	17%	137	81%	169		
Using a laptop has made me more interested in learning.									
Cart	49	25%	84	43%	62	32%	195	32.45	.000
Laptop	10	6%	66	39%	93	55%	169		
Using a laptop has made me want to get better grades.									
Cart	82	42%	59	30%	54	28%	195	25.60	.000
Laptop	30	18%	64	38%	74	44%	168		

Section 2: Student impact. Table 13 summarizes the pattern of student laptop use in the classroom. The groups differed strongly and significantly in all three categories of usage. laptop students were much more likely to use their computers alone every day (74% vs. 46% for cart students). Cart students were significantly more likely to report never working in pairs than were laptop students (38% vs. 14%), whereas laptop students were significantly more likely to report working in pairs "several time a week" (39% vs. 12%). Cart students were also significantly more likely to report never working with a group than were laptop students (58% vs. 24%), whereas laptop students were significantly more likely to report working with a group "Once a week" (59% vs. 31%). These results point to a greater collaborative learning environment for laptop classrooms.

Table 13

Frequency of Responses by Pattern of Student Use

	Never		**Once a Week**		**Several Times a week**		**Almost every day**		**Total**		
Usage	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	χ^2	***p-value***
By yourself											
Cart	5	3%	49	25%	51	26%	88	46%	193	38.63	.000
Laptop	0	0%	10	6%	33	20%	123	74%	166		
With one other student											
Cart	74	38%	90	47%	23	12%	6	3%	193	46.59	.000
Laptop	24	14%	68	41%	64	39%	9	6%	165		
With a group or team											
Cart	111	58%	60	31%	19	10%	3	2%	193	43.42	.000
Laptop	40	24%	96	59%	18	11%	10	6%	165		

Section 3: Subject use. Table 14 shows the pattern of student laptop use by subject. Results contrast sharply for language arts (χ2=188.14, *p*=.001), math (χ2 = 38.62, *p*=.001) and social studies (χ2 = 57.61, $p < .001$) where computers were rarely used in the cart group. Close to half (40%) of the cart students as compared to only 3% of the laptop students "Never" used laptops in language arts. The difference is more dramatic at the other end of the spectrum.

Laptop students were significantly more likely than cart students (48% vs. 2%) to respond that they used laptops for language arts “Almost every day.”

Both groups had less use of laptops for mathematics, although the laptop students did use their computers more often. Significantly more cart students responded that they “Never” used laptops in math (63% vs. 31%), whereas laptop students were significantly more likely to respond that they used laptops in math “Once a week” (60% vs. 34%).

No significant differences between the groups emerged for science as both the cart and laptop students reported using their laptops between “Once a week” and “Several times a week.” In social studies, cart students were more likely to respond “Never” (26% vs. 7%) and laptop students were more likely to respond “Almost every day” (23% vs. 3%). The fact that the laptop students reported using laptops for language arts (48%) and social studies (23%) “Almost every day”, may again point to a specific teaching curriculum in those classrooms that may differ from cart classrooms.

Table 14

Frequency of Responses by Pattern of Subject Use

	Never		Once a Week		Several Times a week		Almost every day		Total		
Usage	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	χ^2	***p-value***
Language Arts											
Cart	77	40%	90	47%	23	12%	3	2%	193	188.14	.000
Laptop	4	3%	23	14%	57	35%	78	48%	162		
Mathematics											
Cart	122	63%	65	34%	5	3%	1	1%	193	38.62	.000
Laptop	50	31%	98	60%	11	7%	4	3%	163		
Science											
Cart	27	14%	93	48%	59	31%	14	7%	193	1.95	.584
Laptop	30	19%	71	44%	52	32%	9	6%	162		
Social Studies											
Cart	51	26%	107	55%	30	16%	5	3%	193	57.61	.000
Laptop	12	7%	69	42%	45	28%	37	23%	163		

Section 4: Barriers to use. Table 15 describes results concerning difficulties related to student use of laptop computers. A result that was not unexpected was a significantly higher percentage of laptop students (87%) vs. cart students (75%) reporting that they had “no problem” with regard to typing and/or using the keyboard. Few other difficulties were reported by either group. However, setting up and working on the laptop did cause a slight problem for cart students, but the difference was not significant ($\chi 2$=5.6, *p*=.061).

Table 15

Frequency of Agreement by Degree of Difficulty in Use

	No Problem		Somewhat of a problem		Big Problem		Total		
Difficulty	**N**	**%**	**N**	**%**	**N**	**%**	**N**	χ^2	***p-value***
Having enough electrical outlet to charge the battery									
Cart	134	70%	45	24%	12	6%	191	.98	.612
Laptop	110	66%	47	28%	10	6%	167		
Having enough desk or table space to use the laptop									
Cart	136	71%	52	27%	3	2%	191	2.11	.349
Laptop	128	77%	35	21%	4	2%	167		
Setting up and working on the laptop									
Cart	134	71%	51	27%	5	3%	190	5.60	.061
Laptop	134	81%	29	18%	2	1%	165		
Feeling comfortable enough to use it in class									
Cart	179	94%	12	6%	0	0%	191	1.88	.390
Laptop	158	95%	7	4%	1	1%	166		
Being able to type and/or use the keyboard									
Cart	142	75%	42	22%	6	3%	190	9.12	.010
Laptop	144	87%	17	10%	5	3%	166		

Summary of Student Survey Results. Although both groups indicated positive reactions to the personal impact of using laptop computers, laptop students were significantly more so regarding increased computer skills, having more fun, being more interested in learning, and wishing to get better grades. The groups were also significantly different in all three categories of usage with the laptop students indicating that they were much more likely to use their computers alone every day and to work in pairs several times a week. When looking at student laptop use by subject area, laptop students were significantly more likely than cart students to respond that they used laptops for language arts almost every day and mathematics on a weekly basis. The laptop students were significantly more likely than cart students to use laptops for social studies, however to a lesser degree than for language arts. No significant differences between the groups emerged for science. Few difficulties related to student use of laptop computers were reported by either group, however, the laptop students reported higher confidence levels regarding use of the keyboard.

Teacher Survey

The teacher survey asked both laptop and cart teachers their opinions regarding how the use of laptops impacted them personally and impacted students. The survey also asked how students used the computers and asked them to rate the impact of identified barriers to using the laptops. The sample for the Teacher Survey was very small for both groups, *n*=3 for cart teachers and *n*=9 for laptop teachers. Significant differences in mean values are unlikely to occur with such small sample sizes, therefore only descriptive data are reported.

Section 1: Personal impact. Table 16 summarizes teachers' personal feelings about having their classroom either assigned carts of laptops or their students being assigned individual laptops. The results suggest that laptop teachers; were more likely to agree that they experienced an increase in their personal ability to use computer applications, were more likely to integrate technology into the lesson, increase their interactions with students and parents, and to benefit overall from the program.

Table 16

Average Agreement by Group regarding Personal Impact

	M	*SD*
I have increased my personal ability to use basic computer applications, such as Access, Excel and PowerPoint.		
Cart	3.67	.58
Laptop	4.22	1.30
I am better prepared to create lessons that integrate student use of computers.		
Cart	3.67	.58
Laptop	3.89	1.17
I frequently integrate technology into lessons that I previously taught without the use of computers.		
Cart	2.67	1.15
Laptop	4.00	1.22
I have increased the frequency or emphasis of higher-level learning in my classroom instruction.		
Cart	3.33	.58
Laptop	3.56	1.13
I have increased the frequency or emphasis of project-based learning.		
Cart	3.33	.58
Laptop	3.78	1.09
My school-related interactions with students and parents have increased.		
Cart	2.33	.58
Laptop	3.11	1.17
Overall, being a teacher with the laptop project has been beneficial to me.		
Cart	3.33	.58
Laptop	3.89	1.17

Section 2: Student impact. Table 17 shows the teacher's impression of how having access to laptops either fulltime or in the classroom affected their student's computer skills. All teachers felt the laptops had increased student interest in learning. However, 56% of the laptop teachers but none (0%) of the cart teachers indicated that performance had increased. Most teachers did not see a change in writing skills, although 44% of laptop teachers thought they had increased. Laptop and cart teachers generally agreed that the laptops increased research skills and collaborative ability.

Table 17

Degree of Impact on Student Learning

Impact	Reduced *N*	Reduced %	Same *N*	Same %	Increased *N*	Increased %	Total *N*
Interest in Learning							
Cart	0	0%	0	0%	3	100%	3
Laptop	0	0%	0	0%	9	100%	9
Performance and/or grades							
Cart	0	0%	3	100%	0	0%	3
Laptop	0	0%	4	44%	5	56%	9
Writing skills							
Cart	0	0%	3	100%	0	0%	3
Laptop	0	0%	5	56%	4	44%	9
Research skills							
Cart	0	0%	2	67%	1	33%	3
Laptop	0	0%	0	0%	9	100%	9
Ability to work with other students							
Cart	0	0%	2	67%	1	33%	3
Laptop	0	0%	3	33%	6	67%	9

Section 3: Student use. As seen in Table 18, laptop and cart teacher responses are similar with regard to the pattern of student use of laptops. Students in both groups were perceived to use laptops individually either “Occasionally” or “Always.” On the other hand, two of the three (67%) cart teachers compared with only 1 (11%) of laptop teachers reported that their students used the laptops in pairs “Sometimes.” Usage in groups of three or more showed no pattern.

Table 18

Frequency of Responses by Pattern of Student Use

Usage	Never *N*	Never %	Rarely *N*	Rarely %	Sometimes *N*	Sometimes %	Occasionally *N*	Occasionally %	Always *N*	Always %	Total *N*
Individually											
Cart	0	0%	0	0%	0	0%	1	33%	2	67%	3
Laptop	0	0%	0	0%	0	0%	3	33%	6	67%	9
In pairs											
Cart	0	0%	0	0%	2	67%	1	33%	0	0%	3
Laptop	0	0%	0	0%	1	11%	6	67%	2	22%	9
In groups of three or more students											
Cart	0	0%	1	50%	0	0%	1	50%	0	0%	2
Laptop	2	22%	2	22%	1	11%	2	22%	2	22%	9

Section 4: Barriers to use. Table 19 lists the degree of difficulty teachers have experienced in laptop use. Based on the frequency data, laptop teachers had less difficulty scheduling the laptop cart, since they did not need one. Laptop teachers also had less difficulty scheduling access several days in a row, again because it was not necessary. The cart teachers expressed more difficulty than the laptop teachers concerning charged batteries and working laptops.

Table 19

Frequency of Agreement by Degree of Difficulty in Use

	A lot		Somewhat		A little		None		Total
Degree	N	%	N	%	N	%	N	%	N
Scheduling the laptop cart									
Cart	0	0%	0	0%	2	67%	1	33%	3
Laptop	0	0%	1	11%	0	0%	8	89%	9
Having laptops with charged batteries									
Cart	2	67%	0	0%	0	0%	1	33%	3
Laptop	2	22%	0	0%	3	33%	4	44%	9
Having access to the laptops several days in a row									
Cart	0	0%	2	67%	1	33%	0	0%	3
Laptop	0	0%	1	11%	0	0%	8	89%	9
Having a working laptop for each student									
Cart	2	67%	1	33%	0	0%	0	0%	3
Laptop	2	22%	0	0%	5	56%	2	22%	9
Space on the student's desktop use laptops									
Cart	0	0%	0	0%	2	67%	1	33%	3
Laptop	0	0%	0	0%	4	44%	5	56%	9
Student's skill with software									
Cart	0	0%	0	0%	3	100%	0	0%	3
Laptop	0	0%	1	11%	7	78%	1	1%	9
Time allotted for class									
Cart	1	33%	0	0%	2	67%	0	0%	3
Laptop	0	0%	1	1%	5	56%	3	33%	9
Electrical outlets for charging during class									
Cart	1	33%	1	33%	0	0%	1	33%	3
Laptop	1	11%	1	11%	3	33%	4	44%	9
Student access to a printer									
Cart	0	0%	0	0%	1	33%	2	67%	3
Laptop	1	11%	1	11%	3	33%	4	44%	9
Student's ability to save their work									
Cart	1	33%	0	0%	1	33%	1	33%	3
Laptop	0	0%	2	22%	7	78%	0	0%	9

Summary of Teacher Survey Results. As a group, the teachers conveyed positive reactions about the benefits of students using laptops as a learning tool. The laptop teachers in general reported higher agreement than cart teachers that the use of laptops had increased their personal ability to use computers, to integrate student use of computers into lessons, and to use higher-level and project-based learning in the classroom. There was unanimous agreement that participation in the laptop program increased students' interest in learning, however the laptop teachers had greater agreement that the laptops helped to increase student writing and research skills, and the ability to work with other students. The majority of the laptop teachers also indicated the laptops had increased student performance/grades. There were no notable difficulties reported regarding student use of laptops in the classroom.

DISCUSSION

Results of this study suggest positive impacts of students using laptop computers as learning tools. However, students who had continuous access to the laptop computers had significant advantages over students who only had classroom access to laptops from a mobile laptop cart. These findings are discussed below in reference to the six primary research questions.

IS TEACHING DIFFERENT IN A LAPTOP VS. A CART CLASSROOM?

The Year 1 results indicated greater uses in the laptop classes of student-centered teaching strategies and laptop students' superiority in using the computer as a learning tool as compared to students in non-laptop classes (Ross, Lowther, Plants, & Morrison, 2000). In contrast, the Year 2 study revealed relatively few differences in teaching methods between laptop classes and CE classes equipped with five or more computers. This outcome was not surprising in view of CE classes also having NTeQ-trained teachers and enhanced technology resources. However, consistent across both years of the study was the laptop students' more frequent usage of the computer as a learning tool. Specifically, greater use of word-processing and CD referencing in the laptop classes and "more meaningful" overall usage of the computer.

Year 3 results revealed no significant differences between teaching activities or computer use in the laptop vs. cart classes. The classroom observations revealed that both laptop and cart teachers acted as coach/facilitators, engaged students in sustained writing and the use of computers as a learning tool or resource. Though not significant, the laptop students were engaged in more independent inquiry research as compared to the cart students and were more frequently in classes with a high level of academically focused class time.

When examining student use of computers, the Year 3 data again revealed no significant differences between the laptop and cart classes. Both groups of students primarily worked alone on up-to-date, Internet-connected computers, however the computer skills of the laptop students were somewhat higher than the cart students. Word processing was the most frequently used software by both groups and language arts was most frequently the subject area of the computer activities. Regarding the meaningfulness of the computer activities, most were considered to be somewhat meaningful, with the laptop students more frequently engaging in more meaningful activities than the cart students.

In summary, the lack of difference in classroom practices in laptop vs. cart classes can most likely be attributed to two factors: both the laptop and cart teachers were trained in the NTeQ model and both groups had substantial access to computers for instructional purposes. Thus, the teaching activities in both classes included non-traditional methodologies that integrated student use of computers as a tool to support meaningful learning. However, the following approaches often associated with best practices and improved student learning were infrequently observed in laptop and/or cart classes: cooperative learning, higher-level feedback and questioning, project-based learning, or integration of subject areas. It may be useful to provide additional professional development that reemphasizes the NTeQ Model, which targets these strategies to ensure students experience a well-rounded classroom environment that supports increased student achievement.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR WRITING SKILLS?

The Year 1 and 2 studies revealed that the laptop students demonstrated superior writing skills as compared to the control students. The results from the Year 3 study followed the same trend, with laptop students showing significant advantages over cart students on the four dimensions of Ideas and Content, Organization, Style, and Conventions. Although the Year 3 results reveal educationally important impacts, the effect sizes were directionally lower than those from Year 2 (Ideas and Content: Yr 2 = +90, Yr 3 = + 67; Organization: Yr 2 = +83, Yr 3 = +37; Style: Yr 2 = +94, Yr 3 = +34; Conventions: Yr 2 = +59, Yr 3 = + 33). Thus suggesting that students with continuous access to laptops have advantages over those who only use laptops during class, and even a greater advantage over students in classrooms limited 5 or more computers to be shared by all students.

Although the observation data did not reveal significant differences in classroom practices, laptop students more frequently used word processing and the Internet for language arts activities and independent inquiry/research. In addition, a majority of the laptop students felt the computers had increased their interest in learning, made learning more fun, and increased their overall computer skills. Perhaps the above factors, along with 24-hour access to the laptops, contributed to overall writing ability of the laptop students.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR APPROACH TO PROBLEM SOLVING?

The problem-solving test was first administered as a part of the Year 2 study and repeated again in the Year 3 study. Both the Year 2 and Year 3 results showed the laptop students outperforming the control students on five of the seven problem-solving components. However, as with the writing test, there was a Year 2 to Year 3 decrease in the effect sizes of these differences. The Effect Sizes for Year 2 ranged from +. 38 to +.76, where as the Year 3 range was only +.26 to +.55.

As with the writing results, even though significant differences in classroom practices were not revealed, laptop students more frequently engaged in independent inquiry/research and more frequently used the Internet – both of which could perhaps enhance student's problem-solving performance (e.g., understanding a problem, identifying what is needed to solve the problem, how to use technology to solve the problem) . The laptop students reported significantly more use of the laptop computers in mathematics and social studies, subject areas into which teachers might more easily integrate problem-based learning activities. They also indicated that they frequently engage in cooperatively learning, which can enhance a student's ability to process and share information. These combined factors conceivably contributed to the laptop students' increased problem-solving ability, however further research with other students is needed.

DO LAPTOP STUDENTS DIFFER FROM CART STUDENTS IN THEIR MATHEMATICS, SCIENCE, AND SOCIAL STUDIES ACHIEVEMENT AT THE 5TH GRADE LEVEL?

The analysis of achievement scores in mathematics (1-4), science and social studies revealed directionally higher means for laptop students as compared to the cart students. However, significant differences between the two groups only occurred on one measure, the Mathematics Benchmark 2 (Geometry and Measurement). This difference did have an

ES = +.44, indicating a moderate effect favoring the laptop group. Since use of the 4th grade MEAP scores as a covariate addressed the initial laptop student advantage, the difference is less likely to be attributed to the laptop students just being "better" students. Other possible factors could be that laptop students used the computers for mathematics activities more frequently than cart students. In addition, even though the classroom practices did not reveal significant differences between laptop and cart groups, the data reveal a pattern of more frequent use in the laptop classes of independent inquiry/research, higher-level instructional feedback, project-based learning, and draw/paint/graphics software. All of which, when combined and used over time, may result in students who are better able to understand geometry and measurement content as listed in state's curriculum mathematics standard II:

> Standard II. Geometry and Measurement
>
> **Standard II.1 Shape and Shape Relationships**
>
> Students develop spatial sense, use shape as an analytic and descriptive tool, identify characteristics and define shapes, identify properties and describe relationships among shapes.
>
> **Standard II.2 Position**
>
> Students identify locations of objects, identify location relative to other objects, and describe the effects of transformations (e.g., sliding, flipping, turning, enlarging, reducing) on an object.
>
> **Standard II.3 Measurement**
>
> Students compare attributes of two objects or of one object with a standard (unit), and analyze situations to determine what measurement(s) should be made and to what level of precision (available at http://.michigan.gov/sde).

HOW DO STUDENTS PERCEIVE THE USE AND ACCESS OF LAPTOP COMPUTERS?

Both the laptop and cart students responded positively when asked about the benefits of using laptop computers for school-related activities. Both groups also indicated that they experienced very few difficulties or barriers to using the laptops in a classroom setting. However, significant differences emerged between the laptop students, who "own" the laptop and have continuous access to it and the cart students who use a school laptop from a mobile cart. For example, the laptop students were significantly more positive that using the laptop had increased their computer skills, made learning more fun and interesting, and provided incentives to get better grades. Personal ownership also seemed to influence the type of laptop usage that occurred during class time as the laptop students were much more likely to use their computers alone every day and to work in pairs several time a week. The subject areas of computer activities were also significantly different in laptop vs. cart classes. The laptop students responded that they used laptops for language arts almost every day and mathematics on a weekly basis. They were also more likely than cart students to use them for social studies, however to a lesser degree than for language arts. No significant differences between the groups emerged for science. These results suggest student attitudes about the educational benefits of using laptops are positively influenced when they "own" a laptop as compared to using school computers stored on a mobile cart.

WHAT DO TEACHERS PERCEIVE AS THE BENEFITS AND PROBLEMS OF INTEGRATING TECHNOLOGY IN LAPTOP VS. CART CLASSROOMS?

Although only a small number of teacher surveys were completed (laptop = 9; cart = 3), the data yielded information that can be suggestive of trends in teachers thoughts regarding the benefits of students using laptops as a learning tool. As with the student survey responses, both the laptop and cart teachers were generally positive about the laptops and unanimously agreed that use of laptops had increased students' interest in learning. However, the laptop teachers had greater agreement than cart teachers that the laptops helped to increase student writing and research skills, their overall performance and grades, and the ability to work with other students. The laptop teachers also reported higher agreement than cart teachers that the use of laptops had increased their personal ability to use computers, to integrate student use of computers into lessons, and to use higher-level and project-based learning in the classroom. There were no notable difficulties reported regarding student use of laptops in the classroom.

Even though the data represent only a few teachers, the results suggest that laptop teachers experience greater benefits from student use of laptops than teachers who use the mobile carts. Perhaps this difference might be attributed to the laptop teachers knowing that students always have computers, so the teachers do not have to create special a "computer lesson plan" because integration is a natural part of everyday teaching and learning. Another contributing factor might be the extra accountability placed on the laptop teachers because parents are paying for the computers and "expect" the laptop teachers to regularly include them in student activities.

CONCLUSIONS

The Year 3 evaluation results are supportive of the beneficial impacts of the laptop program on students and teachers, although the differences were less striking than those found in the Year 1 and 2 studies. The reasons seem largely due to (a) both laptop and cart teachers had received training to integrate technology via the NTeQ model, and (b) both groups had access to one Internet-connected laptop per student during integration lessons. Although both laptop and cart teachers implemented non-traditional methodologies, such as acting as coach/facilitators, engaging students in sustained writing and the use of computers as a learning tool, there was infrequent use of other student-centered strategies found in the NTeQ Model, such as cooperative learning, higher-level feedback and questioning, project-based learning, or integration of subject areas. As mentioned earlier, it may be useful to target professional development toward these strategies to better ensure student engagement in meaningful activities that result in increased student achievement.

The laptop students once again outperformed the control students in writing and problem-solving abilities. Although this year's study did not find significant differences in sustained writing activities for laptop vs. cart students, the laptop students did indicate that they used the computers more extensively for language arts lessons and that the laptop had increased their interest in learning and getting better grades. These differences combined with the fact that the laptop students clearly had more time to use the computers for classroom and homework activities are suggestive that a causal connection to higher writing ability is very likely. Similarly, laptop students' continuous access to computers and more frequent engagement in independent inquiry and research, use of the Internet and cooperative learning could easily be construed as contributing to their enhanced ability to process information and solve problems. With regard to only one difference emerging between laptop and cart student achievement results in mathematics, science, and social studies, the data from this evaluation are too limited to offer a supportive argument for the results. However, the higher achievement on mathematics benchmark 2 could conceivably be associated to laptop students more frequent use of computers in mathematics, along with the previously listed benefits.

In conclusion, even though the classroom environments and practices in laptop and cart classrooms are very similar, the laptop students emerge with more confidence in the educational benefits of using computers and with better writing and problem-solving skills. Thus the continuous access and added responsibility of having personal computers results in students being better prepared to meet the challenges offered in today's highly technical society. However, the feasibility of providing every student with a laptop is financially unrealistic. Therefore, if laptop carts were made more readily available to K-12 teachers trained in the NTeQ approach, perhaps cart students could achieve benefits similar to the laptop students. Although, these results are promising, it is clear that further research that investigates student access to and educational use of laptops is needed.

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Appendix A

Michigan Curriculum Standards and Benchmarks for:

Mathematics 1-4
Science
Social Studies

Section II • Michigan

Content Standards and Working Draft Benchmarks

MATHEMATICS - Elementary

CONTENT STANDARDS	*BENCHMARKS*
I. Patterns, Relationships and Functions Content Standard 1: Students recognize similarities and generalize patterns, use patterns to create models and make predictions, describe the nature of patterns and relationships, and construct representations of mathematical relationships. (Patterns)	1. Recognize, describe and extend numerical and geometric patterns. 2. Represent and record patterns and relationships in a variety of ways including tables, charts and pictures. 3. Use patterns to describe real world phenomena. 4. Explore various types of numeric and geometric patterns (repeating, growing, shrinking). 5. Apply their experiences with patterns to help solve problems and explore new content.
Content Standard 2: Students describe the relationships among variables, predict what will happen to one variable as another variable is changed, analyze natural variation and sources of variability, and compare patterns of change. (Variability and Change)	1. Recognize change and variability when it occurs in a variety of settings. 2. Recognize that change is often predictable, but variable, and that patterns emerge that help to describe the change. 3. Explore change, and realize that changes are frequently interdependent. 4. Use tables, charts, open sentences and hands-on models to represent change and variability. 5. Begin to describe and differentiate between types of relationships, especially repeating, growing and shrinking patterns. 6. Explore variability and change in a variety of contexts, investigations and problems.
II. Geometry and Measurement Content Standard 1: Students develop spatial sense, use shape as an analytic and descriptive tool, identify characteristics and define shapes, identify properties and describe relationships among shapes. (Shape and Shape Relationships)	1. Recognize and name familiar shapes in one, two and three dimensions such as lines, rectangles and spheres and informally discuss the shape of a graph. 2. Describe the attributes of familiar shapes. 3. Compare, sort and classify familiar shapes. 4. Draw and build familiar shapes. 5. Explore ways to combine, dissect and transform shapes. 6. Recognize parallel and perpendicular line segments and figures that have similarity and/or congruence. 7. Use shape, shape properties and shape relationships to describe the physical world and to solve problems.
Content Standard 2: Students identify locations of objects, identify location relative to other objects, and describe the effects of transformations (e.g., sliding, flipping, turning, enlarging, reducing) on an object. (Position)	1. Locate and describe objects in terms of their position, including front, back, inside, outside, right, left, over, under, next to, between and locations on the number line, on a coordinate graph and on a map. coordinates, vectors and limits. 2. Locate and describe objects in terms of their orientation, direction and relative position, including up, down, front, back, N- S- E- W, flipped, turned, translated; recognize symmetrical objects and identify their lines of symmetry. 3. Explore what happens to the size, shape and position of an object after sliding, flipping, turning, enlarging or reducing it. 4. Locate the position of points or objects described by two or more conditions; locate all the points (locus) that satisfy a given condition. 5. Use concepts of position, direction and orientation to describe the physical world and to solve problems.
Content Standard 3: Students compare attributes of two objects, or of one object with a standard (unit), and analyze situations to determine what measurement(s) should be made and to what level of precision. (Measurement)	1. Compare attributes of objects; develop standard units of measurement; and select and use standard tools for measurement. 2. Identify the attribute to be measured and select the appropriate unit of measurement for length, mass (weight), area, perimeter, capacity, time, temperature and money. 3. Develop strategies for estimating measures and compare the estimates to the results of the measurement; decide if an estimate is "a good 4. Explain the meaning of measurements and recognize that the number of units it takes to measure an object is related to the size of the unit. 5. Explore scale drawings, models and maps and relate them to measurements of real objects. 6. Apply measurement to describe the real world and to solve problems.
III. Data Analysis and Statistics Content Standard 1: Students collect and explore data, organize data into a useful form, and develop skill in representing and reading data displayed in different formats. (Collection, Organization and Presentation of Data)	1. Collect and explore data through counting, measuring and conducting surveys and experiments. 2. Organize data using concrete objects, pictures, tallies, tables, charts, diagrams and graphs. 3. Present data using a variety of appropriate representations and explain the meaning of the data. 4. Identify what data are needed to answer a particular question or solve a given problem, and design and implement strategies to obtain, organize and present those data.
Content Standard 2: Students examine data and describe characteristics of a distribution, relate data to the situation from which they arose, and use data to answer questions convincingly and persuasively. (Description and Interpretation)	1. Read and explain data they have collected and organized themselves and progress to reading data from other sources. 2. Describe the shape of the data using informal language. 3. Draw, explain and justify conclusions, such as trends based on data. 4. Raise and answer questions about the source, collection, organization and presentation of data, as well as the conclusions drawn from the data; explore biases in the data.

	5. Formulate questions and problems and gather and interpret data to answer those questions.
Content Standard 3: Students draw defensible inferences about unknown outcomes, make predictions, and identify the degree of confidence they have in their predictions. (Inference and Prediction)	1. Make and test hypotheses. 2. Conduct surveys, samplings and experiments to solve problems and answer questions of interest to them. 3. Formulate and communicate arguments and conclusions based on data and evaluate their arguments and those of others. 4. Make and explain predictions based on data. 5. Make predictions to answer questions and solve problems.
IV. Number Sense and Numeration Content Standard 1: Students experience counting and measuring activities to develop intuitive sense about numbers, develop understanding about properties of numbers, understand the need for and existence of different sets of numbers, and investigate properties of special numbers. (Concepts and Properties of Numbers)	1. Develop an understanding of whole numbers and read, write and count using whole numbers; investigate basic concepts of fractions and decimals. 2. Investigate and develop an understanding of the base-10 place-value system. 3. Develop an understanding of the properties of numbers (e.g., order) and of the properties of the special numbers 0 and 1. 4. Apply their understanding of number systems to model and solve problems.
Content Standard 2: Students recognize that numbers are used in different ways such as counting, measuring, ordering and estimating, understand and produce multiple representations of a number, and translate among equivalent representations. (Representation and Uses of Numbers)	1. Represent whole numbers, fractions and decimals using concrete, pictorial and symbolic representations. 2. Explore and recognize different representations for the same number and explain why they are the same. 3. Investigate ways numbers are used (e.g., counting, ordering, naming, locating, measuring). 4. Develop strategies for estimating quantity and evaluate the reasonableness of their estimates. 5. Select appropriate numbers and representations in order to solve problems.
Content Standard 3: Students investigate relationships such as equality, inequality, inverses, factors and multiples, and represent and compare very large and very small numbers. (Number Relationships)	1. Compare and order numbers using “equal,” “less than” or “greater than.” 2. Use part-whole relationships to explore numbers, develop number concepts and understand computation. 3. Classify numbers as even or odd and explore concepts of factors and multiples. 4. Explain the meaning of powers and roots of numbers and use calculators to compute powers and square roots. 5. Apply their understanding of number relationships in solving problems.

(available at http://.michigan.gov/sde)

SCIENCE - Elementary

CONTENT STANDARDS	***BENCHMARKS***
I. Construct New Scientific and Personal Knowledge Content Standard 1: All students will ask questions that help them learn about the world; design and conduct investigations using appropriate methodology and technology; learn from books and other sources of information; communicate their findings using appropriate technology; and reconstruct previously learned knowledge. (Constructing New Scientific Knowledge)	1. Generate reasonable questions about the world based on observation. (*Key concepts:* See Using Scientific Knowledge. *Real-world contexts:* See Using Scientific Knowledge.) 2. Develop solutions to unfamiliar problems through reasoning, observation, and/or experiment. (*Key concepts:* See Using Scientific Knowledge. *Realworld contexts:* See Using Scientific Knowledge.) 3. Manipulate simple mechanical devices and explain how they work. (*Key concepts:* Names and uses for parts of machines, such as levers, wheel and axles, pulleys, inclined planes, gears, screws, wedges. *Real-world contexts:* Simple mechanical devices, such as bicycles, bicycle pumps, pulleys, faucets, clothespins.) 4. Use simple measurement devices to make metric measurement. (*Key concepts:* Measurement units—milliliters, liters, teaspoon, tablespoon, ounce, cup, millimeter, centimeter, meter, gram. *Measurement tools:* Measuring cups and spoons, measuring tape, balance or scale. *Real-world contexts*: Making simple mixtures, such as food, play dough, papier mache; measuring height of a person, mass of a ball.) 5. Develop strategies and skills for information gathering and problem solving. (*Tools:* Sources of information, such as reference books, trade books, periodicals. *Real-world contexts:* Seeking help from peers, adults, libraries, other resources.) 6. Construct charts and graphs and prepare summaries of observations. (*Key concepts:* Increase, decrease, steady. *Tools:* Graph paper, rulers, crayons. *Real-world contexts*: Examples of simple charts and graphs like those found in a newspaper.)
II. Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge Content Standard 1: All students will analyze claims for their scientific merit and explain how scientists decide what constitutes scientific knowledge; how science is related to other ways of knowing; how science and technology affect our society; and how people of diverse cultures have contributed to and influenced developments in science. (Reflecting on Scientific Knowledge)	1. Develop an awareness of the need for evidence in making decisions scientifically. (*Key concepts:* Data, evidence, sample, guess, opinion. *Realworld contexts:* Deciding whether an explanation is supported by evidence in simple experiments.) 2. Show how science concepts can be interpreted through creative expression such as language arts and fine arts. (*Key concepts:* Poetry, expository work, painting, drawing, music, diagrams, graphs, charts. *Realworld contexts:* Explaining simple experiments using paintings and drawings; describing natural phenomena scientifically and poetically.) 3. Describe ways in which technology is used in everyday life. (*Key concepts:* Provide faster and farther transportation and communication, organize information and solves problems, save time. *Real-world contexts:* Cars, other machines, radios, telephones, computer games, calculators, appliances.) 4. Develop an awareness of and sensitivity to the natural world. (*Key concepts:* Appreciation of the balance of nature and the effects organisms have on each other, including the effects humans have on the natural world. *Real-world contexts:* See Using Scientific Knowledge.) 5. Develop an

	awareness of contributions made to science by people of diverse backgrounds. (*Key concepts:* Scientific contributions made by people of diverse cultures and backgrounds. *Real-world contexts:* See Using Scientific Knowledge.)
III. Use Scientific Knowledge from the Life Sciences in Real-World Contexts Content Standard 1: All students will apply an understanding of cells to the functioning of multicellular organisms; and explain how cells grow, develop and reproduce. (Cells)	1. Describe cells as living systems. (*Key concepts:* Life functions—growth, development, reproduction, response to environment, movement. All parts of living things are made of cells. *Realworld contexts:* Common plant, animal or protist cells: Elodea leaf cells, onion skin cells, human cheek cells, Paramecium.)
Content Standard 2: All students will use classification systems to describe groups of living things; compare and contrast differences in the life cycles of living things; investigate and explain how living things obtain and use energy; and analyze how parts of living things are adapted to carry out specific functions. (Organization of Living Things)	1. Compare and classify familiar organisms on the basis of observable physical characteristics. (*Key concepts:* Plant and animal parts—backbone, skin, shell, limbs, roots, leaves, stems, flowers. *Real-world contexts:* Animals that look similar—snakes, worms, millipedes; flowering and nonflowering plants; pine tree, oak tree, rose, algae.) 2. Describe vertebrates in terms of observable body parts and characteristics. (*Key concepts:* Vertebrate characteristics—fur, scales, feathers, horns, claws, eyes, quills, beaks, teeth, skeleton, muscles, cells. *Realworld contexts:* Vertebrate and nonvertebrate animals, such as humans, cow, sparrow, goldfish, spider, starfish, and animals listed above.) 3. Describe life cycles of familiar organisms. (*Key concepts:* Life cycle stages—egg, young, adult, seed, flower, fruit. *Real-world contexts:* Common plants and animals such as beans, apples, butterflies, grasshoppers frogs, birds.) 4. Compare and contrast food, energy, and environmental needs of selected organisms. (*Key concepts:* Life requirements—food, air, water, minerals, sunlight, space, habitat. *Real-world contexts:* Germinating seeds, such as beans, corn; aquarium or terrarium life, such as guppy, goldfish, snail.) 5. Describe functions of selected seed plant parts. (*Key concepts:* Plant parts—roots, stems, leaves, flowers, fruits, seeds. *Real-world contexts:* Common edible plant parts, such as bean, cauliflower, carrot, apple, tomato, spinach.)
Content Standard 3: All students will investigate and explain how characteristics of living things are passed on through generations; explain why organisms within a species are different from one another; and explain how new traits can be established by changing or manipulating genes. (Heredity)	1. Give evidence that characteristics are passed from parents to young. (*Key concepts:* Participants—parent, young. Characteristics—hair color, eye color, skin color, leaf shape, leaf size. *Real-world contexts:* Example of mature and immature organisms, such as dogs/puppies, cats/kittens, maple trees/saplings,
Content Standard 4: All students will explain how scientists construct and scientifically test theories concerning the origin of life and evolution of species; compare ways that living organisms are adapted (suited) to survive and reproduce in their environments; and analyze how species change through time. (Evolution)	1. Explain how fossils provide evidence about the nature of ancient life. (*Key concepts:* Types of evidence—fossil, extinct, ancient, modern life forms. *Real-world contexts:* Common contexts—plant and animal fossils, museum dioramas and paintings/drawings of ancient life and/or habitats.) 2. Explain how physical and/or behavioral characteristics of organisms help them to survive in their environments. (*Key concepts:* Characteristics—adaptation, fitness, instinct, learning, habit. Traits and their adaptive values—sharp teeth or claws for catching and killing prey, color for camouflage. *Real-world contexts:* Common vertebrate adaptations, such as white polar bears, sharp claws and sharp canines for predators, changing colors of chameleon; behaviors, such as migration, communication of danger, adaptation to changes in the environment.)
Content Standard 5: All students will explain how parts of an ecosystem are related and how they interact; explain how energy is distributed to living things in an ecosystem; investigate and explain how communities of living things change over a period of time; describe how materials cycle through an ecosystem and get reused in the environment; and analyze how humans and the environment interact. (Ecosystems)	1. Identify familiar organisms as part of a food chain or food web and describe their feeding relationships within the web. (*Key concepts:* Producer, consumer, predator, prey, decomposer, habitat. *Real-world contexts:* Food chains and food webs involving organisms, such as rabbits, birds, snakes, grasshoppers, plants.) 2. Explain common patterns of interdependence and interrelationships of living things. (*Key concepts:* Producer, consumer, predator, prey, decomposer, habitat. *Real-world contexts:* Relationships among plants and animals in an ecosystem—symbiotic relationships, such as insects and flowering plants, birds eating fruit and spreading seeds; parasitic relationships, such as human and mosquitoes, trees and mistletoe.) 3. Describe the basic requirements for all living things to maintain their existence. (*Key concepts:* Needs of life—food, habitat, water, shelter, air, light, minerals. *Real-world contexts:* Selected ecosystems, such as an aquarium, rotting log, terrarium, backyard, local pond or wetland, wood lot.) 4. Design systems that encourage growing of particular plants or animals. (*Key concepts:* Needs of life—food, habitat, water, shelter, air, light, minerals. *Realworld contexts:* Ecosystems managed by humans, including farms, ranches, gardens, lawns, potted plants.) 5. Describe positive and negative effects of humans on the environment. (*Key concepts:* Human effects on the environment—garbage, habitat destruction, land management, resource management. *Realworld contexts:* Household wastes, school wastes, waste water treatment, habitat destruction due to community growth, reforestation projects, establishing parks or other green spaces.)
IV. Use Scientific Knowledge from the Physical Sciences in Real-World Contexts Content Standard 1: All students will measure and describe the things around us; explain what the world around us is made of; identify and describe forms of energy; and explain how electricity and magnetism interact with matter. (Matter and Energy)	1. Classify common objects and substances according to observable attributes: color, size, shape, smell, hardness, texture, flexibility, length, weight, buoyancy, states of matter, or magnetic properties. (*Key concepts:* Texture—rough, smooth. Flexibility—rigid, stiff, firm, flexible, strong. Smell—pleasant, unpleasant. States of matter—solid, liquid, gas. Magnetic properties—attract, repel, push, pull. Size—large, small, larger, smaller. Buoyancy—sink, float. Color—common color words. Shape—circle, square, triangle, rectangle, oval. Weight—heavy, light, heavier, lighter. *Realworld contexts:* Common objects, such as desks, coins, pencils, buildings, snowflakes; common substances, including—solids, such as copper, iron, wood, plastic, Styrofoam; liquids, such as

	water, alcohol, milk, juice, gasoline; gases such as air, helium, water vapor.) 2. Measure weight, dimensions, and temperature of appropriate objects and materials. (*Key concepts:* Linear dimensions—length, width, height, long, short, wide, narrow, tall, short, taller, shorter. Units of measure (both standard and nonstandard)—meters, centimeters, others. *Measurement tools:* Ruler, meter stick, balance or scale, thermometer. *Real-world contexts:* Common objects such as those listed above.) 3. Identify properties of materials which make them useful. (*Key concepts:* Useful properties—unbreakable, waterproof, light, conducts electricity, conducts heat, attracted to a magnet. *Realworld contexts:* Appropriate selection of materials for a particular use, such as waterproof raincoat, cotton or wool for clothing, glass for windows, metal pan to conduct heat, copper wire to conduct electricity.) 4. Identify forms of energy associated with common phenomena. (*Key concepts:* Energy, work, heat, sound, food energy, energy of motion, electrical. *Real-world contexts:* Appropriate selection of energy and phenomena, such as appliances like a toaster or iron that use electricity, sun's heat to melt chocolate, water wheels, wind-up toys, warmth of sun on skin, windmills, music from guitar.) 5. Describe the interaction of magnetic materials with other magnetic and non-magnetic materials. (*Key concepts:* Magnetic/non-magnetic, magnetic poles, magnetic attraction and repulsion. *Tools:* Magnetic compass. *Real-world contexts:* Common magnets, using a magnetic compass to find direction.) 6. Describe the interaction of charged materials with other charged or uncharged materials. (*Key concepts:* Charging by rubbing or touching, electric attraction and repulsion. *Real-world contexts:* Static cling, lightning, sparks.) 7. Describe possible electrical hazards to be avoided at home and at school. (*Key concepts:* Shock, wall outlet, hazards. *Real-world contexts:* Electric outlets, power lines, frayed electric cords, electric appliances, lightning.)
Content Standard 2: All students will investigate, describe and analyze ways in which matter changes; describe how living things and human technology change matter and transform energy; explain how visible changes in matter are related to atoms and molecules; and how changes in matter are related to changes in energy. (Changes in Matter)	1. Describe common physical changes in matter—size, shape, melting, freezing, dissolving. (*Key concepts:* States of matter—solid, liquid, gas. Changes in size and shape—bending, tearing, breaking. Changes in state of matter—melting, freezing, dissolving, invisible heat source. *Real-world contexts:* Changes in size or shape of familiar objects, such as making snowballs, breaking glass, crumbling cookies, making clay models, carving wood, breaking bones; changes in state of water or other substances, such as freezing of ice cream, or ponds, melting wax or steel.) 2. Prepare mixtures and separate them into their component parts. (*Key concepts:* Mixture, solution. Separation techniques—filtration, using sieves, dissolving soluble substances, magnets, floating vs. sinking, distillation. *Tools:* Filter paper, funnels, magnets, sieves, beakers, solar stills. *Real-world contexts:* Mixtures of various kinds—salt and pepper, iron filings and sand, sand and sugar, rocks and wood chips, sand and gravel.) 3. Construct simple objects that fulfill a technological purpose. (*Materials:* Rubber bands, paper, corks, scrap wood. *Real-world contexts:* Simple bridges, boats, planes, ramps that can be made from common materials.)
Content Standard 3: All students will describe how things around us move and explain why things move as they do; demonstrate and explain how we control the motions of objects; and relate motion to energy and energy conversions. (Motion of Objects)	1. Describe or compare motions of common objects in terms of speed and direction. (*Key concepts:* Words—east, west, north, south, right, left. Speed words—fast, slow, faster, slower. *Real-world contexts:* Motions of familiar objects in two dimensions, including rolling or thrown balls, wheeled vehicles, sliding objects.) 2. Describe how forces (pushes or pulls) are needed to speed up, slow down, stop, or change the direction of a moving object. (*Key concepts:* Changes in motion—speeding up, slowing down, turning. Common forces—push, pull, friction, gravity. *Real-world contexts:* Playing ball, moving chairs, sliding objects.) 3. Use simple machines to make work easier. (*Key concepts:* Inclined planes, levers, pulleys, gears, wheel and axles, screws, wedges. *Real-world contexts:* Block and tackles, ramps, screwdrivers, can openers.)
Content Standard 4: All students will describe sounds and sound waves; explain shadows, color, and other light phenomena; measure and describe vibrations and waves; and explain how waves and vibrations transfer energy. (Waves and Vibrations)	1. Describe sounds in terms of their properties (pitch, loudness). (*Key concepts:* Pitch—high, low. Loudness—loud, soft. *Real-world contexts:* Sound from common sources, such as musical instruments, radio, television, animal sounds, thunder, human voices.) 3. Describe light from a light source in terms of its properties. (*Key concepts:* Brightness—bright, dim. Color of light—red, orange, yellow, green, blue, violet. *Real-world contexts:* Light from common sources, such as sun, stars, light bulb, colored lights, firefly, candle, flashlight.) 4. Explain how light illuminates objects. (*Key concepts:* Light source, illumination, path of light. *Real-world contexts:* Objects illuminated by light from common sources.) 5. Explain how shadows are made. (*Key concepts:* Shadow, blocked path. *Real-world contexts:* Shadows made by putting objects in the path of light from common sources, including sunlight, light bulbs, projectors.)
V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts Content Standard 1: All students will describe the earth's surface; describe and explain how the earth's features change over time; and analyze effects of technology on the earth's surface and resources. (Geosphere)	1. Describe major features of the earth's surface. (*Key concepts:* Types of features—rivers, mountains, deserts, plains, valleys, oceans. *Real-world contexts:* Examples of local surface features, such as hills, valleys, rivers; pictures of nonlocal land features, including mountains, deserts.) 2. Recognize and describe different types of earth materials. (*Key concepts:* Materials—sand, clay, silt, soil, rock, minerals. Origins—molten rock, river beds, natural vs. manufactured. *Tools:* Hand lens. *Real-world contexts:* Samples of earth materials, such as rocks, sand, soil, ores.) 3. Explain how rocks and fossils are used to understand the history of the earth. (*Key concepts:* Fossils, extinct animals, dinosaurs, age of fossils, rock layers. Also see Evolution benchmarks. *Realworld contexts:* Fossils found in gravel, mines and quarries, museum displays; local examples of layered rocks.) 4. Describe natural changes in the earth's surface. (*Key concepts:* Causes of changes—volcanoes, earthquakes, erosion, rivers. Results of change—valleys, mountains, cracks.

	Real-world contexts: Places around the school where erosion has occurred, such as gullies formed in down-hill gravel areas, cracks in asphalt.) 5. Describe uses of materials taken from the earth. (*Key concepts:* Transportation—oil into gasoline. Building materials—sand into glass, ores into metals, gravel into concrete and asphalt. Energy—coal burned to produce electricity; uranium for nuclear power. Water—drinking, cleaning, cooling. *Real-world contexts:* Examples of uses of earth materials, such as concrete walls, glass windows, metal chairs.) 6. Demonstrate means to recycle manufactured materials and a disposition toward recycling. (*Key concepts:* Recyclable materials—paper, metal, glass, plastic. Anti-pollution activities—reduce, reuse, recycle. *Real-world contexts:* Collections of recyclable materials, plans for recycling at home and school.)
Content Standard 2: All students will demonstrate where water is found on earth; describe the characteristics of water and how water moves; and analyze the interaction of human activities with the hydrosphere. (Hydrosphere)	1. Describe how water exists on earth in three states. (*Key concepts:* Liquid—visible, flowing, melting, dew, steam. Solid—hard, visible, freezing, ice. Gas—invisible, evaporation, water vapor. Also see Atmosphere and Weather benchmarks. *Real-world contexts:* Examples of water in each state, including dew, rain, snow, ice, steam; examples of melting, freezing, and evaporating. *Real-world contexts:* Examples of water in each state, including dew, rain, snow, ice, steam; examples of melting, freezing, and evaporating.) 2. Trace the path that rain water follows after it falls. (*Key concepts:* Precipitation—rain, clouds, fog, run-off. Flow—downhill, to ocean, underground. Bodies of water—streams, rivers, lakes, oceans. *Real-world contexts:* Examples of water flowing locally, including gutters, drains, streams, wetlands.) 3. Identify sources of drinking water. (*Key concepts:* Water sources—wells, springs, Great Lakes, rivers. *Real-world contexts:* Examples of local sources of drinking water, including wells, rivers, lakes.) 4. Describe uses of water. (*Key concepts:* Domestic uses—drinking, cleaning, food preparation. Public uses—generate electricity, recreation, irrigation, transportation. *Real-world contexts:* Examples of local occasions when water is used, including car wash, swimming pools, fire hydrants, drinking, food preparation, cleaning.)
Content Standard 3: All students will investigate and describe what makes up weather and how it changes from day to day, from season to season and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere. (Atmosphere and Weather)	1. Describe the atmosphere. (*Key concepts:* Air as a substance. Clouds, dew. Also see Hydrosphere benchmarks and Solar System benchmarks. *Realworld contexts:* Daily atmospheric conditions; examples of using air to do work, including balloons, fans.) 2. Describe weather conditions and climates. (*Key concepts:* Temperature—cold, hot, warm, cool. Cloud cover—cloudy, fog, partly cloudy. Precipitation—rain, snow, hail. Wind—breezy, windy, calm. Severe weather—thunderstorms, lightning, tornadoes, high winds, blizzards. Climates—desert (hot and dry), continental (seasonal changes), tropical (hot and humid), polar. *Tools:* Thermometer, wind sock. *Realworld contexts:* Daily changes in weather; examples of severe weather; examples of climates, including desert, mountain, polar, temperate.) 3. Describe seasonal changes in weather. (*Key concepts:* Seasons—fall, winter, spring, summer. *Real-world contexts:* Examples of visible seasonal changes in nature.) 4. Explain appropriate safety precautions during severe weather. (*Key concepts:* Safety precautions—safe locations, sirens, radio broadcasts, severe weather watch and warning. *Real-world contexts:* Examples of local severe weather, including thunderstorms and tornadoes, that change with the seasons; examples of local community safety precautions, including weather bulletins and tornado sirens.)
Content Standard 4: All students will compare and contrast our planet and sun to other planets and star systems; describe and explain how objects in the solar system move; explain scientific theories as to the origin of the solar system; and explain how we learn about the universe. (Solar System, Galaxy and Universe)	1. Describe the sun, moon and earth. (*Key concepts:* Planet, star, sphere, space, solar system, larger/smaller, closer/farther, heat, light. *Realworld contexts:* Photos and videos from space of the sun, earth, moon, other planets.) 2. Describe the motions of the earth and moon around the sun. (*Key concepts:* Perceived movement of the sun across the sky, orbit, month, year, day, night, spin, calendar. *Real-world contexts:* Models or diagrams of the positions and relative distances between the sun, earth, moon; models showing the motions of the earth and moon; outdoor observing of the sun's motion.)

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SOCIAL STUDIES – Late Elementary

Content standards	**Benchmarks**
I. Historical Perspective Content Standard 1: All students will sequence chronologically the following eras of American history and key events within these eras in order to examine relationships and to explain cause and effect: The Meeting of Three Worlds (beginnings to 1620); Colonization and Settlement (1585- 1763); Revolution and the New Nation (1754-1815); Expansion and Reform (1801-1861); and Civil War and Reconstruction (1850-1877); The Development of the Industrial United States (1870-1900); The Emergence of Modern America (1890-1930); The Great Depression and World War II (1929- 1945);	1. Measure chronological time by decades and centuries. 2. Place major events in the development of their local community and the state of Michigan in chronological order. 3. Place major events in the early history of the United States in chronological order.

Post War United States (1945-1970); and Contemporary United States (1968-present). (Time and Chronology).	
Content Standard 2: All students will understand narratives about major eras of American and world history by identifying the people involved, describing the setting, and sequencing the events. (Comprehending the Past)	1. Summarize the sequence of key events in stories describing life from the past in their local community, the state of Michigan and other parts of the United States. 2. Use narratives and graphic data to compare the past of their local community, the state of Michigan and other parts of the United States with present day life in those places. 3. Recount the lives and characters of a variety of individuals from the past representing their local community, the state of Michigan and other parts of the United States. 4. Identify and explain how individuals in history demonstrated good character and personal virtue.
Content Standard 3: All students will reconstruct the past by comparing interpretations written by others from a variety of perspectives and creating narratives from evidence. (Analyzing and Interpreting the Past)	1. Use primary sources to reconstruct past events in their local community. 2. Interpret conflicting accounts of events in both Michigan and United States history and analyze the viewpoints of the authors. 3. Compose simple narratives of events from the history of the state of Michigan and the United States.
Content Standard 4: All students will evaluate key decisions made at critical turning points in history by assessing their implications and long-term consequences. (Judging Decisions from the Past)	1. Identify problems from the past that divided their local community, the state of Michigan, and the United States and analyze the Interests and values of those involved. 2. Select decisions made to solve past problems and evaluate those decisions in terms of ethical considerations, the interests of those affected by the decisions, and the short- and long-term consequences in those decisions.
II. Geographic Perspective Content Standard 1: All students will describe, compare, and explain the locations and characteristics of places, cultures, and settlements. (People, Places and Cultures)	1. Locate and describe cultures and compare the similarities and differences among the roles of women, men, and families. 2. Locate and describe diverse kinds of communities and explain the reasons for their characteristics and locations. 3. Locate and describe the major places, cultures, and communities of the nation and compare their characteristics.
Content Standard 2: All students will describe, compare, and explain the locations and characteristics of ecosystems, resources, human adaptation, environmental impact, and the interrelationships among them. (Human/Environment Interaction)	1. Explain basic ecosystem concepts and processes. 2. Describe the location, use, and importance of different kinds of resources and explain how they are created and the consequences of their use. 3. Describe the major physical patterns, ecosystems, resources, and land uses of the state, region, and country and explain the processes that created them. 4. Explain how various people and cultures have adapted to and modified the environment.
Content Standard 3: All students will describe, compare, and explain the locations and characteristics of economic activities, trade, political activities, migration, information flow, and the interrelationships among them. (Location, Movement and Connections)	1. Describe major kinds of economic activity and explain the factors influencing their location. 2. Describe the causes, consequences, routes and movement of major migration to the United States. 3. Explain how transportation and communication link people and communities. 4. Describe some of the major movements of goods, people, jobs and information within Michigan and the United States and explain the reasons for the movements.
Content Standard 4: All students will describe and compare characteristics of ecosystems, states, regions, countries, major world regions, and patterns and explain the processes that created them. (Regions, Patterns and Processes)	1. Draw sketch maps of the community, region, and nation. 2. Describe places, cultures, and communities in the United States and compare them with those in other regions and countries. 3. Describe the geography of Michigan at major times in its history and explain the reasons for its change.
Content Standard 5: All students will describe and explain the causes, consequences, and geographic context of major global issues and events. (Global Issues and Events)	1. Locate major world events and explain how they impact people and the environment.
III. Civic Perspective Content Standard 1: All students will identify the purposes of national, state, and local governments in the United States, describe how citizens organize government to accomplish their purposes, and assess their effectiveness. (Purposes of Government)	1. Distinguish among local, state, and national government in the United States and describe the roles of government institutions at all three levels. 2. Give examples of authority and the use of power without authority. 3. Give reasons for limiting the power of government.
Content Standard 2: All students will explain the meaning and origin of the ideas, including the core democratic values expressed in the Declaration of Independence, the Constitution, and other foundational documents of the United States. (Ideals of American Democracy)	1. Interpret the development and summarize the main points in the Declaration of Independence. 2. Interpret the meaning of specific rights guaranteed by the Constitution including religious liberty, free expression, privacy, property, due process of law and equal protection of the law. 3. Explain responsibilities citizens have to uphold constitutional rights.
Content Standard 3: All students will describe the political and legal processes created to make decisions, seek consensus and resolve conflicts in a free society. (Democracy in Action)	1. Describe what state and federal courts are expected to do. 2. Describe issues that arise over constitutional rights.
Content Standard 4: All students will explain how American governmental institutions, at the local, state, and federal levels, provide for the limitation and sharing of power and how the nation's political system provides for the exercise of power. (American Government and Politics)	1. Distinguish among making, enforcing, and interpreting laws. 2. Explain how law is used to manage conflict in American society. 3. Explain the basic organization of the local, state, and federal governments. 4. Describe how citizens participate in election campaigns.

Content Standard 5: All students will understand how the world is organized politically, the formation of American foreign policy and the roles the United States plays in the international arena. (American Government and World Affairs)	1. Explain various ways that nations of the world interact with each other. 2. Describe events in other countries that have affected Americans and, conversely, events within
IV. Economic Perspective Content Standard 1: All students will describe and demonstrate how the economic forces of scarcity and choice affect the management of personal financial resources, shape consumer decisions regarding the purchase, use, and disposal of goods and services and affect the economic well-being of individuals and society. (Individual and Household Choices)	1. Explain why people must face scarcity when making economic decisions. 2. Identify the opportunity costs in personal decision making situations. 3. Use a decision making model to explain a personal choice. 4. Analyze the costs, benefits, and alternatives to using consumer credit.
Content Standard 2: All students will explain and demonstrate how businesses confront scarcity and choice when organizing, producing, and using resources, and when supplying the marketplace. (Business Choices)	1. Distinguish between natural resources, human capital, and capital equipment in the production of a good or service. 2. Distinguish among individual ownership, partnership, and corporation.
Content Standard 3: All students will describe how government decisions on taxation, spending, public goods, and regulation impact what is produced, how it is produced, and who receives the benefits of production. (Role of Government)	1. Use a decision making model to explain a choice involving a public good or service. 2. Distinguish between the economic roles of local, state, and federal governments and cite examples of each. 3. Use a local example to assess the effectiveness of the government at providing public goods or resolving an economic dispute.
Content Standard 4: All students will explain how a free market economic system works, as well as other economic systems, to coordinate and facilitate the exchange, production, distribution, and consumption of goods and services. (Economic Systems)	1. Explain how prices are determined in a market economy and how they serve as a means of allocating resources.
Content Standard 5: All students will describe how trade generates economic development and interdependence and analyze the resulting challenges and benefits for individuals, producers, and government. (Trade)	1. Trace the national origin of common household items and the trade flows which brought them to the United States. 2. Describe benefits of international trade to consumers and producers. 3. Describe how businesses are involved in trade as producers, distributors, importers, and exporters.
V. Inquiry Content Standard 1: All students will acquire information from books, maps, newspapers, data sets and other sources, organize and present the information in maps, graphs, charts and timelines, interpret the meaning and significance of information, and use a variety of electronic technologies to assist in accessing and managing information. (Information Processing)	1. Locate information about local, state and national communities using a variety of traditional sources, electronic technologies, and direct observations. 2. Organize social science information to make maps, graphs and tables. 3. Interpret social science information about local, state, and national communities from maps, graphs, and charts.
Content Standard 2: All students will conduct investigations by formulating a clear statement of a question, gathering and organizing information from a variety of sources, analyzing and interpreting information, formulating and testing hypotheses, reporting results both orally and in writing, and making use of appropriate technology. (Conducting Investigations)	1. Pose a social science question about Michigan or the United States. 2. Gather and analyze information using appropriate information technologies to answer the question posed. 3. Construct an answer to the question posed and support their answer with evidence.
VI. Public Discourse and Decision Making Content Standard 1: All students will state an issue clearly as a question of public policy, trace the origins of the issue, analyze various perspectives people bring to the issue and evaluate possible ways to resolve the issue. (Identifying and Analyzing Issues)	1. Pose local, state, and national policy issues as questions. 2. Explain how a particular public issue became a problem and why people disagree about it. 3. Evaluate possible resolutions of a public issue.
Content Standard 2: All students will engage their peers in constructive conversation about matters of public concern by clarifying issues, considering opposing views, applying democratic values, anticipating consequences, and working toward making decisions. (Group Discussion)	1. Engage each other in conversations which attempt to clarify and resolve issues pertaining to local, state, and national policy.
Content Standard 3: All students will compose coherent written essays that express a position on a	1. Compose a short essay expressing a decision on a local, state, or national policy issue.

public issue and justify the position with reasoned arguments. (Persuasive Writing)	
VII. Citizen Involvement Content Standard 1: All students will consider the effects of an individual's actions on other people, how one acts in accordance with the rule of law, and how one acts in a virtuous and ethically responsible way as a member of society. (Responsible Personal Conduct)	1. Report how their behavior has been guided by concern for the law. 2. Engage in activities intended to contribute to solving a local, state or national problem they have studied.

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Appendix B

Writing Rubric

Writing Scoring Guide

	Mature (4)	Capable (3)	Developing (2)	Emerging (1)
Ideas and Content	Central idea is clear and focused. Writer uses creative, insightful detail.	Central idea is clear and focused and the writer adds basic detail.	Central idea is somewhat developed, and the writer includes some detail; however, focus may shift and some details are extraneous.	Writing may show little or no development of the central idea or may be too limited in length to demonstrate proficiency
Organization	Organization helps unify the piece and moves the reader easily through the text.	Organization is apparent but may be too obviously structured; may be extraneous detail which interferes with unity.	An attempt at organization is apparent although ideas may lack a sense of wholeness	Organization may be lacking; or may seem arbitrary.
Style	Voice of writer comes through with rich and precise word choice and effective use of varied sentence structure.	Writing demonstrates varied sentence structure as well as appropriate word choices, including some engaging vocabulary.	Vocabulary is limited or inappropriate to the task; sentence structure may be simple.	Vocabulary is limited; sentences may be choppy, incomplete or rambling
Conventions	Text demonstrates varied use of standard writing conventions with few errors.	Surface feature errors may occasionally distract the reader, but they don't interfere with understanding.	Surface feature errors make understanding difficult.	Numerous surface feature errors may severely interfere with understanding.

Appendix C

Problem-Solving Task

Problem-Solving: Letter to Teachers

Dear Teacher:

As part of this year's Anytime Anywhere Learning project, we have developed a problem-solving task for sixth grade students. We have selected your classroom to complete this task. The following are the directions.

Directions and Information

1. Students are to tell us *how* they will solve the problem rather than solving it.
2. Please allow the students to enter their answers on a computer so that all are word-processed.
3. Students should not put their name or any other identifying mark on their paper.
4. Please read the attached announcement before the students start working on the task.
5. Allow 45 minutes to complete the task.

Please read to class before distributing the problem solving task:

A group of Wayne State University researchers are working with our school district to find out the best way to use computers in your classroom. They are asking you to tell them how you would solve a problem.

Whether you participate or not is, of course, up to you. What you tell them will be kept secret. They will not tell your teacher, principal, or parents what you have said. They might mention what some of the students have said in one of their reports, but they will not mention your name.

In any case, you should still remember that if there's any question that you do not want to answer, that's ok.

Appendix D

Problem-Solving Rubric

Problem-Solving Rubric

Component/Rating	Level 1	Level 2	Level 3
Understands problem	The overall problem-solving approach demonstrates a very limited understanding of the problem.	The overall problem-solving approach somewhat demonstrates a general understanding of the problem.	The overall problem-solving approach strongly demonstrates clear understanding of the problem.
Identifies what is known about the problem	Provides a very limited or no description of what is known.	Provides an incomplete description of what is known	Provides a complete and detailed list of what is known about problem
Identifies what needs to be known to solve the problem	Provides no or a very limited relationship between data/what needs to be known and problem	Provides some reasoning as to how data/what needs to be known are related to problem-solving	Provides developed rationale as to how data/what needs to be known are related to solving the problem
Determines how the data needs to be manipulated to solve the problem	Does not address data manipulation	Provides indication that data must be manipulated	Describes specific ways of manipulating data to solve problem
Describes use of technology	Description of technology use is not included or very limited, e.g., the computer will be used to get information.	Describes specific technology/software that will be used to solve problem, but only provides general tasks to be completed, e.g., the Internet will be used to find information.	Describes specific technology/software and specific tasks that will be used to solve problem, e.g., the Internet will be used to find information about recycling paper.
Describes how to present findings	Provides no or very limited detail as to how results will be presented	Provides a general description of how results will be presented	Describes details of how and what results will be presented
Collaborative Learning	No mention of collaboration or independent orientation	Describes limited collaboration, mostly for sharing information or obtaining help	Describes a collaborative orientation with assigned responsibilities and extensive interactions with partners