Computers on wheels: an alternative to ‘each one has one’

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Abstract
Four fifth-grade classrooms embarked on a modified ubiquitous computing initiative in the fall of 2003. Two 15-computer wireless laptop carts were shared among the four classrooms in an effort to integrate technology across the curriculum and affect change in student learning and teacher pedagogy. This initiative—in contrast to other one-to-one programmemeess and stationary labs—offers public schools alternatives to budget constraints and instructional-space overhead. Results indicate positive teacher technology competence and confidence, as well as instructional strategies that were student-centred made meaningful uses of technology. Teacher technological knowledge and efficacy, pedagogical knowledge, and a supportive school community seem to be strong indicators for impacting technology integration in this context.

Introduction
As access to computer technologies continues to increase (National Center for Educational Statistics, 2001), there has also been a movement to decrease the computer-to-student ratio. Windschitl and Sahl (2002) report that ‘more than a thousand schools nationwide have committed themselves to some form of laptop computer initiative’ (p. 165). The goals of these types of initiatives vary, but include increased student achievement and learning, increased home and school interaction and increased technology access for low-income families (Penuel et al, 2002).

A number of evaluations and case studies have documented mixed results with ubiquitous computing approaches (eg, Edwards, 2003; Hill, Reeves, Grant, Wang & Hans, 2005; Lowther, Ross & Morrison, 2003; Mowen, 2003; Rockman et al, 1997, 2000). Successes have included improved student achievements; broader access and equity for students; increased communication among faculty, administrators, students and parents and reports of reductions in absenteeism and school dropout rates. However, teachers and students alike have struggled with managing learning issues such as time on task; pedagogical issues such as transitioning to student-centered learning and
classroom management issues such as monitoring student distractions with email, the Internet and gaming.

Advocating a one-to-one student-to-computer ratio is appealing, and the goals are admirable. A similar statewide initiative (Bickford, Tharp, McFarling & Beglau, 2002) has attempted to compromise on the student-to-computer ratio with two students to every one computer. However, this programme has also been challenged with the lack of change in teacher practice. And more recently, funding limits have placed the onus of support on the individual school districts.

The funding for such innovative programmes cannot be discounted. Supplying every student and teacher with an Internet-capable computer is a substantial capital commitment for school budgets. One principal admits his middle school has ‘invested well over $1 million in laptop technology... since 2000’ (Mowen, 2003, Introduction section, para. 3). For this reason many early laptop initiatives were implemented in private and parochial schools (eg, Hill et al., 2005; Newhouse, 2001; Rockman et al., 1997).

As an alternative to a one-to-one initiative, some schools have purchased mobile laptop carts, or computers on wheels (COWs). These carts of 5 to 25 mobile computers are typically wireless and can be wheeled from classroom to classroom as needed. Schools have used this model to promote collaboration among students and aid in transitioning among groups of students and in classroom settings (eg, Gwaltney, 2003). In addition, these mobile carts have also offered an alternative to committing instructional space to computer laboratories.

Little research has been reported about these mobile laboratories. This small evaluation study documents the findings of one school’s experience, identified by the pseudonym Green River Elementary, with using mobile laptop carts to affect change in teacher practice and student learning. The laptop programme evaluation was structured around four primary research questions that focused on classroom practices, degree and type of technology use, academically focused time, student engagement, teacher technology skills, teacher attitudes toward technology as well as student and teacher reactions to the programme. The research questions were:

1. In what ways has the effectiveness of instruction through the use of student laptop computers been impacted?
2. To what degree and in what ways have teachers integrated technology with classroom instruction?
3. To what degree do teachers use methodologies that stress higher-order learning and student-centred learning activities?
4. To what degree has the laptop programme impacted teacher attitudes toward technology?

**Design**

The evaluation design was based on both quantitative and qualitative data collected from classroom observations, teacher surveys and focus groups with teachers and
students. The four fifth-grade teachers and their intact classrooms at Green River Elementary participated in the evaluation.

**Context**
Green River Elementary, serving grades K–8, was situated in a suburban city outside a large urban city in the southeast United States. The laptop programme was a pilot project designed to determine the impact of changing the ways students learn and teachers instruct in a technology-enhanced learning environment. The original concept included having a laptop for each student in fifth grade, replicating Rockman et al’s (1997) concentrated implementation model, with dedicated technology integration training for the fifth-grade teachers. Unfortunately, costs and lack of significant grant funding prohibited the implementation of the project to this extent.

Instead, the context for the laptop programme and this evaluation consisted of four fifth-grade classes in which two Apple iBook wireless laptop carts were shared among the four fifth-grade teachers’ classrooms. In addition, the four teachers each received a personal Apple PowerBook laptop to use during the initiative and individually focused their professional development opportunities on technology-related training offered through the local school district. Each of the fifth-grade teachers taught one of the core subject areas (ie, language arts, math, science and social studies). So every fifth-grade student rotated through each teacher’s classroom during the day. The number of students per class ranged from 23 to 27.

**Data collection**
Instruments and focus group interviews were used to collect the evaluation data (three classroom observation measures, two teacher surveys and four interviews). Trained observers, including the primary researcher and a doctoral candidate in education, conducted nine classroom observations in the Spring of 2004. The classroom visits were pre-arranged observations using three instruments described below. Descriptive statistics were used for analyses.

**School observation measure**
The School Observation Measure© (SOM) examined the frequency of usage of 24 instructional strategies, including traditional practices (eg, direct instruction and independent seatwork) and alternative, predominately student-centred methods associated with educational reforms (eg, cooperative learning, project-based learning, inquiry, discussion, using technology as a learning tool) (Ross, Smith & Alberg, 1999). The observer summarised the frequency with which each of the strategies was observed 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 used 3-point scales (low, moderate, high) to rate (1) the use of academically focused instructional time and (2) the degree of student attention and interest.

After receiving the manual and instructions in a group session, each observer participated in sufficient practice exercises to ensure that his or her data are comparable with
those of experienced observers (ie, the trainers). 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.

Targeted observations were conducted in this evaluation to examine classroom instruction during prearranged one-hour sessions in which the teachers demonstrated a prepared lesson using technology. Observation forms were completed every 15 minutes of the lesson then condensed on a summary form. To triangulate the reliability of these results, multiple researchers observed class sessions.

Survey of computer use
As a companion to the SOM, the Survey of Computer Use© (SCU) examined the availability and student use of technology and software applications (Lowther & Ross, 1999). The SCU was completed as part of the one-hour observation. Four primary types of data were recorded: (1) computer capacity and currency; (2) configuration, (3) student computer ability and (4) student activities while using computers. Computer capacity and currency was defined as the age and type of computers available for student use and whether or not Internet access was available. Configuration referred to the number of students working on each computer (eg, alone, in pairs or in small groups). Student computer ability was assessed by recording the number of students who were computer literate (eg, easily used the software features/menus, saved or printed documents) and the number of students who easily used the keyboard to enter text or numerical information. Student use of computers was focused on the types of computer-mediated activities; subject areas of activities and software being used. The computer activities were divided into three categories based on the type of software tool (1) production tools (eg, word processing, databases, spreadsheets, draw/paint/graphics, presentation authoring, concept mapping, planning), (2) Internet/research tools (eg, Internet browser, CD reference materials, communications) and (3) educational software (eg, drill-practice/tutorial, problem solving, process tools). This section ends by identifying the content subject area of each computer activity (ie, language arts, mathematics, social studies, science and others). Like the SOM, the computer activities and software being used are summarised and recorded using a 5-point rubric that ranges from (0) Not Observed to (5) Extensively Observed. The final section of the SCU was an ‘overall rubric’ designed to assess the degree—in four levels—to which the activity reflects the ‘meaningful use’ of computers as a tool to enhance learning (1 = low-level use of computers, 2 = somewhat meaningful, 3 = meaningful, 4 = very meaningful).

The reliability of the SCU was determined in a study involving pairs of trained observers conducting SCU observations in 42 targeted visits to classrooms that were scheduled to have students using technology. Results from the study revealed that in the overall, the paired observers selected the identical SCU response on 86% of the items with all other responses being only one rating apart. When looking at the subcategories of the SCU, the percentages of times that paired observers selected the same responses were
as follows: (1) computer capacity and currency, 83%; (2) configuration, 95%; (3) student computer ability, 70%; (4) student activities while using computers, 92%; (5) subject areas of computer activities, 88% and (6) overall rubric rating meaningfulness of computer activities, 88% (Lowther & Ross, 1999).

**Rubric for student-centered activities (RSCA)**

Finally, the Rubric for Student-Centered Activities© rated the degree of learner engagement in seven specific instructional strategies during the one-hour observations: 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 (Lowther, Ross & Plants, 2000). These strategies reflected emphasis on higher-order learning and the attainment of a deep understanding of content and whether or not technology was utilised as a component of the strategy. Such learning outcomes seemed consistent with those likely to be engendered by well-designed, real-world linked exercises, projects or problems utilising technology as a learning tool. Each item included a 2-part rating scale. The first was a 4-point scale, ranging from (1) indicating a very low level of application to (5) representing a high level of application. The second was a ‘Yes/No’ option to the question: ‘Was technology used?’ with a space provided to write a brief description of the technology use.

**Teacher technology questionnaire (TTQ)**

Two surveys were used to obtain self-perceptions of attitudes and skills. The TTQ collected teacher perceptions of computers and technology. In the first section, teachers rated their level of agreement with 20 statements regarding five technology-related areas: (1) impact on classroom instruction; (2) impact on students; (3) teacher readiness to integrate technology; (4) overall support for technology in the school and (5) technical support. Items were rated with a 5-point Likert-type scale that ranges from (1) Strongly Disagree to (5) Strongly Agree. A sixth section was added specifically to address perceptions of the laptop programme.

**Technology skills assessment**

In addition to the TTQ, the Technology Skills Assessment (TSA) assessed the self-perceived technological abilities of the teachers in these areas: (1) computer basics; (2) software basics; (3) multimedia basics; (4) Internet basics; (5) advanced skills and (6) using technology for learning. The survey consisted of 47 items with three levels (1 = not at all, 2 = somewhat, 3 = very easily). All of the questions were aligned to the International Society for Technology in Education’s (ISTE) National Educational Technology Standards (NETS).

**Focus groups**

Focus groups were conducted with all four fifth-grade teachers and eight to ten fifth-grade students in the fall of 2003 and again in May 2004. A semi-structured interview protocol was used in order to allow for variation in the order and phrasing of the questions, as well as probes to specific individuals (Patton, 1990). Questions addressed
three areas: (1) the use of laptop computers; (2) expectations for the laptop programme and (3) reservations about the laptop programme. Analysis of the data followed a general qualitative analysis process (Cresswell, 1998; Merriam, 1998). From audio recordings and facilitator notes, themes were derived.

**Results**

Below is a brief summary of the results grouped by classroom observation measures, surveys and focus groups.

**Classroom observation measures**

The data for nine classroom observations were collected with SOMs, SCUs and RSCAs. Results from each measure are described in the sections below.

**SOM**

The SOM (see Table 1 for observed data summary) revealed nine instructional strategies that were observed during the targeted observations ($n = 9$): (1) project-based learning, (2) technology as a learning tool or resource, (3) teacher acting as coach/facilitator, (4) higher level instructional feedback (written or verbal) to enhance student learning, (5) use of higher-level questioning strategies, (6) independent seatwork (self-paced worksheets, individual assignments), (7) independent inquiry/research on the part of students, (8) technology as a learning tool or resource (eg Internet research, spreadsheet or database creation, multi-media, CD-ROM, Laser disk).

<table>
<thead>
<tr>
<th>Strategies</th>
<th>None (%)</th>
<th>Rarely (%)</th>
<th>Occasionally (%)</th>
<th>Frequently (%)</th>
<th>Extensively (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct instruction (lecture)</td>
<td>88.9</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cooperative/collaborative learning</td>
<td>55.6</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Higher level instructional feedback (written or verbal) to enhance student learning</td>
<td>66.7</td>
<td>11.1</td>
<td>0.0</td>
<td>22.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Project-based learning</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Use of higher-level questioning strategies</td>
<td>77.8</td>
<td>22.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Teacher acting as a coach/facilitator</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>88.9</td>
</tr>
<tr>
<td>Independent seatwork (self-paced worksheets, individual assignments)</td>
<td>44.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>55.6</td>
</tr>
<tr>
<td>Independent inquiry/research on the part of students</td>
<td>55.6</td>
<td>0.0</td>
<td>0.0</td>
<td>11.1</td>
<td>33.3</td>
</tr>
<tr>
<td>Technology as a learning tool or resource (eg Internet research, spreadsheet or database creation, multi-media, CD-ROM, Laser disk)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Summary items**

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academically focused class time</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Level of student attention/interest/engagement</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
independent seatwork, (5) cooperative/collaborative learning, (6) independent inquiry/research on the part of the students, (7) higher level instructional feedback to students, (8) use of higher-level questioning strategies and (9) direct instruction. These strategies were observed during 11.1% of the visits to 100% of the classroom visits. Notably, project-based learning and technology as a learning tool or resource were observed during every visit (100%). Teacher acting as coach/facilitator (88.9%) and independent seatwork (55.6%) were observed at least 50% of the time. Academically focused class time and student engagement were observed to be high 100% of the time.

SCU
Observations \((n = 9)\) using the SCU documented that 11 or more computers were available for student use in the classrooms in all of the visits (100%). All of the computers (100%) were observed to be up-to-date, and all the computers (100%) were connected to the Internet. It is important to note that during two of the prearranged visits, the school’s internal network was intermittent. So while the computers were capable of accessing the Intranet and Internet, students were unable to do so consistently. Students primarily worked alone (88.9%) and in pairs (11.1%). Computer literacy skills were observed to be consistently very good (100%), and keyboarding skills were also very good (100%).

Three student computer activities were observed in at least 40% of the classroom visits: Internet browsers (66.7%); draw/paint/graphics (44.4%) and electronic presentations (44.4%). See Table 2 for a summary of observed computer activities and meaningfulness. Computer activities were observed in all subject areas. Productivity tools were observed in all the subject areas from 11.1% to 33.3% of the time. Likewise, Internet/research tools were observed in all of the subject areas from 11.1% to 22.2% of the time. Drill/practice/tutorial were the only educational software observed and only observed in mathematics (11.1%). Meaningful use of computers were extensively observed in over 50% of the visits (55.6%) and very meaningful computer applications were extensively observed in over 30% of the classrooms (33.3%). So, meaningful or very meaningful use of computers were observed almost 90% (88.9%) of the time.

RSCA
Five of the seven activities noted on the RSCA were observed during visits \((n = 9)\): (1) project-based learning (100%); (2) students as producers of knowledge (88.9%); (3) cooperative learning (44.4%) and (4) independent inquiry/research (44.4%) and higher-level questioning strategies (11.1%). Notably, project-based learning was noted during all observations and students as producers of knowledge were observed during almost 90% of the visits. The most meaningful applications of student-centred activities, that is, those activities where somewhat strong and strong applications were observed in at least 30% of the classroom visits, included cooperative learning (44.4%); project-based learning (77.7%) and students as producers of knowledge (77.8%). Technology was used to support three of these strategies: project-based learning (100%); cooperative learning (44.4%) and independent inquiry/research (44.4%). See Table 3 for a summary of observed RSCA data.
Table 2: Survey of computer use data summary (n = 9): frequency of observed activities

<table>
<thead>
<tr>
<th>Production tools used by students</th>
<th>Not observed (%)</th>
<th>Rarely (%)</th>
<th>Occasionally (%)</th>
<th>Frequently (%)</th>
<th>Extensively (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>77.8</td>
<td>11.1</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Draw/paint/graphics</td>
<td>55.6</td>
<td>11.1</td>
<td>11.1</td>
<td>0.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Presentation (eg, MS PowerPoint)</td>
<td>55.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>44.4</td>
</tr>
<tr>
<td>Other: (eg, Timeliner)</td>
<td>88.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>11.1</td>
</tr>
</tbody>
</table>

| Internet/research tools           |                 |            |                  |                |                 |
| Internet browser (eg, Netscape)   | 33.3            | 22.2       | 11.1             | 33.3           |

| Educational software              |                 |            |                  |                |                 |
| Drill/practice/tutorial           | 88.9            | 0.0        | 11.1             | 0.0            |

<table>
<thead>
<tr>
<th>Subject areas of computer activities</th>
<th>Language arts (%)</th>
<th>Mathematics (%)</th>
<th>Science (%)</th>
<th>Social studies (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production tools</td>
<td>33.3</td>
<td>33.3</td>
<td>11.1</td>
<td>22.2</td>
</tr>
<tr>
<td>Internet/research tools</td>
<td>22.2</td>
<td>11.1</td>
<td>11.1</td>
<td>22.2</td>
</tr>
<tr>
<td>Educational software</td>
<td>0.0</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall meaningful use of computers</th>
<th>Not observed (%)</th>
<th>Rarely (%)</th>
<th>Occasionally (%)</th>
<th>Frequently (%)</th>
<th>Extensively (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low level use of computers</td>
<td>88.9</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Somewhat meaningful use of computers</td>
<td>88.9</td>
<td>11.1</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Meaningful use of computers</td>
<td>22.2</td>
<td>0.0</td>
<td>11.1</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Very meaningful use of computers</td>
<td>66.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>33.3</td>
</tr>
</tbody>
</table>
Surveys
Two surveys (TTQ and TSA) were administered to the teachers prior to a focus group interview in May 2004. Results of the two surveys are presented below.

TTQ
The fifth-grade teachers ($n = 4$) responded very positively to the programme. Table 4 provides descriptive statistics for sections of the TTQ. Mean scores for all six sections were between (4) *Agree* and (5) *Strongly Agree*. This indicates the teachers felt the laptop programme had a positive impact on (1) classroom instruction; (2) technology with students; (3) the teachers’ readiness to integrate technology; (4) the school and district’s overall support for technology; (5) appropriate technical support and (6) a positive attitude toward the laptop programme. Notable are the questions that the teachers responded in unison. Within the section on overall support for technology in the school,
two questions addressed the parent, community and administrative support necessary for technology to impact teaching and learning, both with scores of (5) Strongly Agree. Within the technical support section, the teachers concurred that they could readily answer technology-related questions with a score of (4) Agree. Within the section on attitudes toward the laptop programme, two questions represented the teachers’ enthusiasm for the programme and confidence about their abilities, both with scores of 5 = Strongly Agree. Also notable is the question, ‘School computers are well maintained’, which received the lowest mean score of 3.75 between (3) Neither Disagree nor Agree and (4) Agree. This question, while receiving the lowest mean score also had the largest amount of variance among the respondents (SD = 1.26).

**TSA**

The TSA revealed very high levels of confidence in the fifth-grade teachers (n = 4) to use technology throughout six areas: computers, software, multimedia, Internet, advanced skills and using technology for learning (see Table 5 for summary statistics). Teacher confidence was high in all six areas with mean scores of 2.5 or higher, between (2) Somewhat and (3) Very Easily and very little discrepancy among their ratings (SD = 0.05 to 0.38). The teachers rated themselves highest in Computer Basics (M = 2.98) and Software Basics (M = 2.96). Remarkable is that of the 47 questions on the TSA, the teachers rated their confidence in 30 of the tasks as (3) Very Easily, which constitutes 63.8% of the tasks. Moreover, of the 47 questions, only four were rated below (2) Somewhat.

**Focus groups**

Given the intimate nature of results and interpretations in qualitative research, these are presented together below. Verbatim comments are enclosed in quotation marks to represent most accurately the voice of the teachers and students.

**Teachers**

The teachers primarily discussed two themes: (1) computer use and (2) pressures and concerns.

**Computer use.** The teachers identified online tests; publishing stories; information seeking and research on the Internet; word processing; electronic presentations and

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Table 5: Technology skills assessment data summary (n = 4)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer basics (items 1–11)</td>
<td>2.98</td>
<td>0.05</td>
</tr>
<tr>
<td>Software basics (items 12–17)</td>
<td>2.96</td>
<td>0.08</td>
</tr>
<tr>
<td>Multimedia basics (items 18–21)</td>
<td>2.81</td>
<td>0.24</td>
</tr>
<tr>
<td>Internet basics (items 22–28)</td>
<td>2.61</td>
<td>0.21</td>
</tr>
<tr>
<td>Advanced skills (items 29–37)</td>
<td>2.86</td>
<td>0.11</td>
</tr>
<tr>
<td>Using technology for learning (items 38–47)</td>
<td>2.50</td>
<td>0.38</td>
</tr>
</tbody>
</table>
draw/paint applications as the computer uses they had implemented. They also considered it their responsibility to teach the students about trustworthiness with the laptops and the ‘upkeep’ for the laptops. The teachers were proud of the very few numbers of computers that had been ‘dropped’ by the students. They also felt that in order to leverage the use of the laptops, it was necessary to teach ‘saving’, ‘how to save’ and management routines for using the laptops.

The teachers described that they would like to use the laptops for about ‘50%’ of the time, about ‘two to three hours a day’. However, they felt some challenges prevented them from achieving this goal. Specifically, the scope of the curriculum, as well as state and district standards (ie, ‘student performance indicators’), were difficult to achieve with or without using the laptops. Changes in the district curriculum also made it ‘difficult to schedule’ and plan ahead for the next year.

Pressures and concerns. During the fall semester, the teachers were concerned about the keyboarding skills of the students, as well as ‘maintenance’, ‘upkeep’ and ‘technical support’ for using the laptops. However, in the spring semester, the teachers voiced that they were ‘confident’ of the use of the laptops for instruction and that they could ‘figure out’ most of the technical problems or questions that arose. They also noted that they depended on one another for expertise. Proximity to one another’s classrooms facilitated this learning community.

Similarly, in the fall semester, they described that their colleagues were ‘jealous’ toward the fact that they had laptops; however, their colleagues were also relieved that they ‘did not have to deal with the responsibilities and/or tasks’ that accompany using the laptops for learning. In the spring, this perception continued. One teacher described it as ‘laptop envy’. They felt that some teachers perceived the laptop programme as an ‘extra burden’. Indicative of their growth and comfort levels, however, the teachers noted that their colleagues ‘come to us for questions’ about using computers or technical problems, demonstrating pride in their accomplishments.

In the fall semester, the teachers expressed ‘meeting expectations of the administration’ as a source of pressure toward using the laptops, and ‘meeting standards’ defined by the school district and state as pressures they felt toward not using the laptops. It is simple to discern the conflict these pressures presented toward use and non-use. However, in the spring semester they seemed to have reconciled these. The teachers concurred that they did not feel ‘as much pressure as in the beginning’. Some pressure may have been intrinsic—applied by the teachers—in addition to the extrinsic pressures they identified. Again, pride or efficacy in their endeavors seemed to have mitigated the former pressures.

In the fall semester, concerns about the laptop programme centred on covering content and teaching skills and knowledge that specifically may not be revisited until later grades. The teachers were also concerned that they would be teaching computer skills that the students ‘will not use in other grade levels’. In the spring,
concerns shifted to improvements for the following school year. For example, another fifth-grade teacher would be added. Currently, the core subject areas (i.e., language arts, mathematics, science and social studies) were taught by one of the fifth-grade teachers. So, all the fifth-grade students rotated through each of the teachers. In the fall of 2004, another teacher will be added and she will most likely share teaching responsibilities for one or more content areas. Integrating this teacher into the learning community and ‘logistically figuring it out’ how to use the laptops when the same subject matter is taught in two different classrooms were indicated as challenges and concerns. In addition, technical difficulties such as reliability with the internal network as well as external Internet and server access continued to be concerns for the teachers. They did feel, however, that they were more sensitive and susceptible to these challenges given their reliance on these resources.

Students
Students’ discussions centered on two themes: (1) computer use and (2) students that benefit from using laptops.

Computer use. The students identified electronic presentations; writing ‘stories’; graphing things like an ordered pairs lesson in mathematics; using draw/paint to create an original flower in science and visiting Internet sites for information seeking/research as ways they had used the laptop computers in class. They said in many instances that using the laptop computers was ‘easier’, ‘fun and faster’ and required less ‘writing’. But they also recognised that in some in cases, such as with the flower project in science, it was ‘harder’ than completing the assignment on paper, where they previously used craft materials.

The students reported issues that they felt prevented from using the laptops more in class. These related to technical and logistical topics as well as personal responsibility. Technical problems such as system crashes; ‘freezing’; glitches in the application programmememes; system updates as well as broken keypads and broken cords requiring ‘repair time’ continued to be challenges throughout the school year. Logistical issues primarily centred on the lack of ‘battery power’, which sometimes caused delays in instruction and in a few instances resulted in lost work.

A very strong theme for the students’ use was personal responsibility for the laptops. This message as described by the teachers in their interviews appeared to have been respected by the students. Many students felt that they ‘had to be careful when using the laptops’ so they would not damage them. They also felt that ‘not being responsible’ would prevent them from being able to use the laptops. ‘Dropping the laptops’ was also a concern. But, the students also felt like they were ‘gaining responsibility’ with using the laptops and taking care of them.

At the beginning of the school year, students thought typing—or keyboarding—skills were a problem, preventing or slowing the use of the laptops. They even suggested requiring ‘a typing class’. However, at the end of the year, the students did not include
this with their challenges in using the laptops or with the students they felt benefited most from the laptops’ use.

It is also interesting to note that a few students also felt that they ‘can’t work on [the laptops] all day’. They felt it was implausible. Similarly, students thought if they used the laptops ‘all day’, it ‘might get boring’.

Students that benefit from using laptops. The fifth graders felt that the types of students who benefited most from using the laptops were those that were fast learners or ‘students who learn more’. They also thought peers that had prior knowledge about computers or were ‘into computers’ also benefited. In the fall they felt that students who had ‘high IQs’ benefited, but in the spring, students mentioned that ‘students who are not as smart’ were the ones who were benefiting the most.

The students agreed in the fall and spring that the type of students who did not benefit from using the laptops were those students who ‘don’t care’ and those who ‘don’t listen’ or do not pay attention. One student called these indifferent and lackadaisical students ‘goofers’, explaining that they ‘sit there and do nothing’. They also felt that the ‘smartest kids in class’ benefited least, because ‘they already know’ how to use the laptops and are confident with the content. Similarly, the ‘fast learners’ they felt should have additional resources, because they are ‘held back’ when skills are retaught.

Discussion
The discussion of the findings is presented in association with each of the major research questions below. The small sample limits the ability to generalise these finding to larger populations. More specifically, this research represents the voices of students and teachers in a suburban city, enabling Green River Elementary to document and evaluate their process and progress with this initiative. It is impossible to say if these findings would extrapolate to other populations. As such, these results should be interpreted with caution, and the extent to which these results can be applied in other contexts is situated with the reader.

In what ways has the effectiveness of instruction through the use of student laptop computer been impacted?
While it is difficult to determine increases without baseline—or beginning—data, SOM results indicate the extensive use of cooperative/collaborative learning; project-based learning and the teachers acting as coaches or facilitators. Results from the SCU indicate the extensive use of productivity tools, specifically draw/paint/graphics and electronic presentations and Internet research with Internet browsers. SCU results also suggest wide use across the content areas. Finally, the overall meaningfulness of the computers was observed to be extensive in approximately one-third to half of the classroom visits. The results from the SOM coupled with the results from the SCU point to activities that result in the meaningful use of computers that were based on problems required critical thinking skills and used computer applications to locate, process and/
or manipulate information. Despite the limited scope of technology tools, those tools observed were seen to meaningfully integrate technology to enhance student learning.

Moreover, data from the RSCA revealed that teachers used technology with over 40% of their student-centred learning activities. This finding is not surprising given that the observations were conducted with targeted lessons, where the teachers were asked to demonstrate technology integration. However, specifically notable is that technology was observed in every instance with project-based learning. This is a significant accomplishment given the focus of the initiative on using technology to impact teaching and learning. Plus, technology for student use is often employed best during more ill-defined learning contexts such as project- and problem-based learning (Morrison & Lowther, 2005).

During two of the observations, the school network access was intermittent. As laptop programmes continue, network reliability will impact the effectiveness of instruction with the increased dependence on digital resources such as the Internet, email and networked school servers. Other implementations (eg, Edwards, 2003) have also experienced challenges with unstable or unreliable networks. While statistics may document physical network wiring (cf, National Center for Educational Statistics, 2001), little data details reliability.

To what degree and in what ways have teachers integrated technology with classroom instruction?

The proposed laptop programme included comprehensive technology integration training for the fifth-grade teachers; this was not implemented due to cost and lack of grant support. The teachers, through focus group interviews indicated they had participated in professional development workshops offered through the local school district. They also relied heavily on one another to extend their expertise, creating an informal community of practice (Wenger, 1998) leveraged from their grade team. So, primarily the teachers used their educational philosophies and pedagogy to envision effective technology integration. Pierson (2001) suggests that pedagogical expertise and teacher epistemologies influence technology integration. Likewise, teachers’ personal technology skills impact the meaningfulness of the technology integration activities as well as the instruction and assessment. While this evaluation did not seek to explore teacher epistemologies or pedagogical expertise, there is some evidence from observations and focus group interviews to suggest the fifth-grade teachers’ visions for technology-enhanced teaching and learning represents the intersection of exemplary technological ability and exemplary teaching ability: Pierson’s Category 4.

To what degree do laptop teachers use methodologies that stress higher-order learning and student-centred learning activities?

In almost 90% (88.9%) of the targeted classroom visits, teachers were observed to be extensively acting as a coach or facilitator of learning. Other activities indicative of critical thinking and student engagement were seen in over 30% of the visits. Cooperative/collaborative learning, which was observed extensively in 33.3% of the visits, was
observed to be at least somewhat strong in over 40% of the observations (44.4%). Project-based learning, which was observed in 100% of the visits, was observed to be at least somewhat strong in over 75% of the visits (77.7%). Finally, independent inquiry/research, which was observed in over 40% of the visits (44.4%), was observed to be at least somewhat strong in approximately 10% of the visits (11.1%). These data indicated some use of non-traditional, or more student-centred, instructional methods. Similar initiatives directed at reducing the student-to-computer ratio (eg, Bickford et al, 2002) have reported challenges with teachers’ use of student-centered pedagogy. Pierson (2001) agreed that characterisations of exemplary technology-using teachers represent a combination of content knowledge, pedagogical knowledge and technological knowledge that few teachers may achieve.

The results from this research suggest the fifth-grade teachers have the pedagogical knowledge and skill to implement teaching methods that emphasize higher-order and critical thinking. Since the observations used in this study were prearranged visits, it is impossible to determine the regularity of these strategies throughout the school year. In addition, with a lack of baseline comparative data, it is also impossible to discern whether the fifth-grade teachers employed these methods prior to the laptop initiative.

To what degree has the laptop programme impacted teacher attitudes toward technology?
The fifth-grade teachers were enthusiastic about the laptop programme. Succinctly, the teachers felt the programme had positively impacted their classroom instruction and positively impacted the fifth-grade students. Moreover, the teachers felt they were ready to integrate technology into their instruction. This was corroborated by the focus group interviews as the teachers discussed their ‘confidence’ with the laptops and reconciliation with previous intrinsic and extrinsic pressures. The TSA highlighted the teachers’ expertise in computer basics; software basics; multimedia basics; Internet basics; advanced skills and using technology to support learning. This substantiates previous research (eg, Pierson, 2001; Silvernail & Lane, 2004) that suggests teacher technology skills positively impact technology integration.

Finally, the teachers felt they have the support of the parents; the community; the administration and the technical support necessary to be effective with technology integration and improve student learning. Silvernail and Lane (2004) reported that success with technology integration also appeared to be influenced by key individuals to champion the programme. The parents and school administration, while initially imposing extrinsic pressure on the teachers, may in fact have translated into the types of advocates necessary to support the laptop programme.

Conclusion
From the formative results in this study, the school had positive teacher technology competence and confidence, used instructional strategies that centred on and facilitated student learning and employed classroom practices that engaged students in meaningful technology-supported activities. Pierson’s (2001) case studies emphasized content,
pedagogical and technological knowledge as factors influencing technology integration. Ertmer’s continued work (eg, 1999, 2003; Ertmer, Gopalakrishnan & Ross, 2001) and Windschitl and Sahl (2002) have likewise called attention to teacher beliefs and epistemologies. Windschitl and Sahl (2002) have also identified school culture and perceived support as factors that impact technology integration, specifically in laptop programmes. In the present study, the fifth-grade teachers’ progress toward more student-centred activities, including project-based learning; cooperative/collaborative learning and acting as a coach or facilitator, seems to support this.

As mentioned previously, without baseline data, it is difficult to confirm any causations. However, there were no specific interventions as part of this initiative (ie, professional development training) to affect change in teacher practice. Focus group interview results confirmed any professional development the teachers received was through the school district and targeted specific software applications and not teacher practice and epistemologies. Low student-to-computer-ratio research (eg, Bickford et al, 2002; Hill et al, in press) have documented teachers’ resistance to change practices even over longitudinal cases. So, it may be considered that the present teachers employed the observed strategies prior to the introduction of the laptop carts. However, Windschitl and Sahl (2002) contend that ubiquitous computing offered an avenue for teachers to reconcile dissatisfaction with previous teaching practices by moving to more student-centred instruction. So, the laptop carts may have also presented the opportunity to transition instruction during the implementation. It is equally plausible that there could have been a combination of both prior use and transitional use of student-centred instructional methods.

The interdependence with one another and community of practice established by the fifth-grade teachers also appears to have created an informal culture of support and knowledge sharing (Wenger, 1998). While the teachers may have been novices at the beginning of the school year, clearly all the teachers felt they were skilled enough to use a variety of software applications for meaningful learning and implemented the types of instructional strategies that are consistent with student-centred learning and best uses of technology to support learning. It is also important to consider that this small community may have also provided the support necessary for some of the teachers in this study to make the transition necessary to implement the observed student-centred methods as discussed above. Birman, Desimone, Porter and Garet (2000) and Mouza (2002–2003) suggest collaborations and in-classroom assistance as necessary for teachers to effectively change practice. So, the proximity of classrooms and community support may have provided the localised professional development to successfully integrate technology and student-centred instructional strategies.

The results from this current research emphasized three factors as indicators for change in impacting technology integration: teacher technological knowledge and efficacy; pedagogical knowledge and a supportive community. Further research should expand these results, examining teacher epistemologies; content knowledge; school climate and professional development. Additional research may also examine baseline versus post-
implementation results, specifically for types of instructional strategies and teacher epistemologies, as well as in other contexts such as rural and urban schools. As more schools consider COWs as alternatives to stationary labs and vehicles to affect change in teacher practice and student learning, researchers and school administrators should also consider the differences these approaches have against other one-to-one and two-to-one implementations.

References


